

Missouri Pond Handbook

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Missouri Department of Conservation

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From the water's edge

A pond is more than water held back by a dam. It's a place for deer to stop for a drink in the evening. For raccoons, it's a smorgasbord furnishing tasty delights. To frogs, it is a place to start their young on life's adventure. To fish, it's home sweet home.

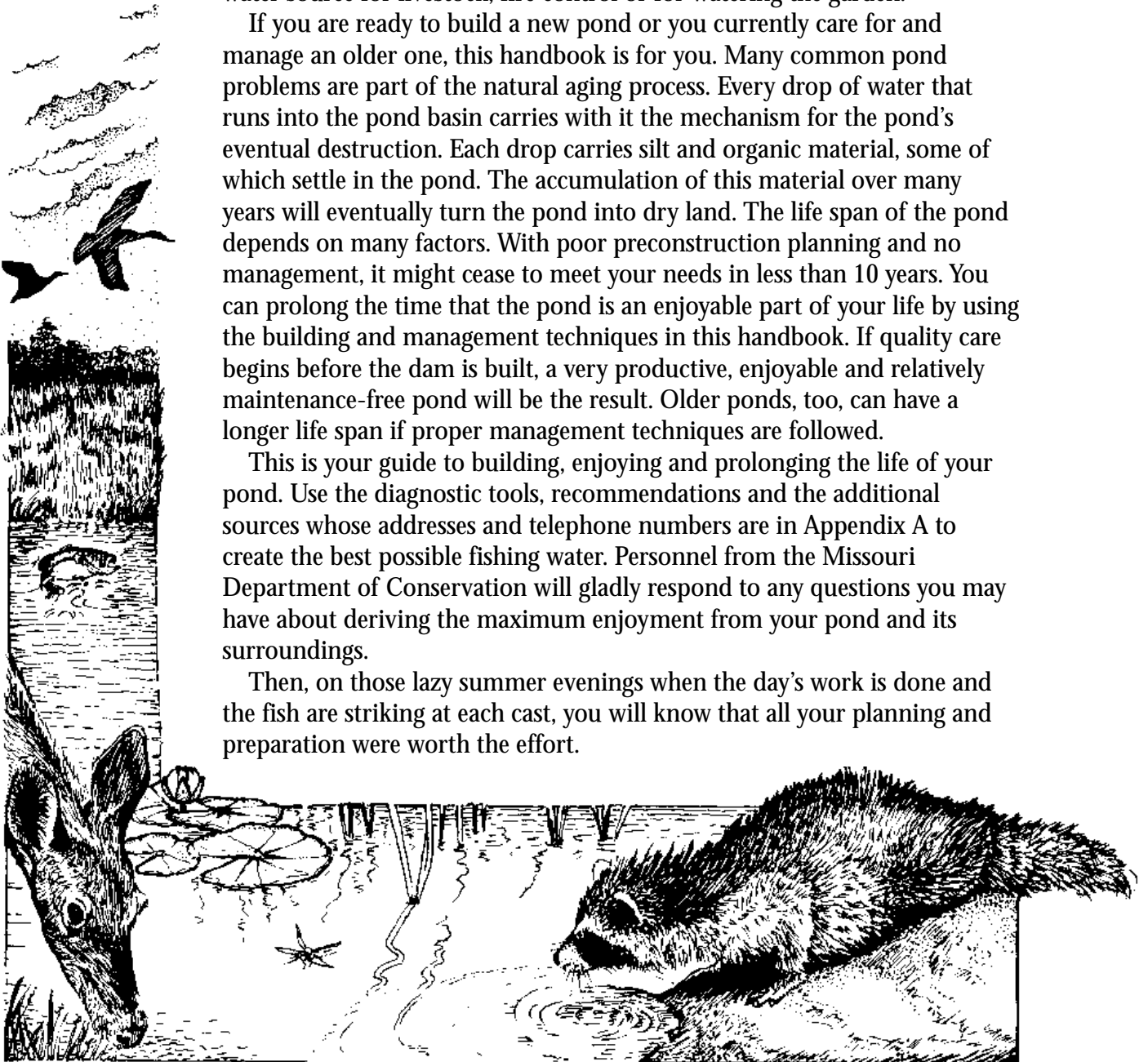
For a pond owner, it might be a place to spend a quiet moment during a busy day, or a place to toss out a line and be rewarded with fresh fish for dinner.

Or perhaps it's just a spot to rest and observe the waterfowl and other wildlife that come for food, water and shelter. Ponds also may provide a water source for livestock, fire control or for watering the garden.

If you are ready to build a new pond or you currently care for and manage an older one, this handbook is for you. Many common pond problems are part of the natural aging process. Every drop of water that runs into the pond basin carries with it the mechanism for the pond's eventual destruction. Each drop carries silt and organic material, some of which settle in the pond. The accumulation of this material over many years will eventually turn the pond into dry land. The life span of the pond depends on many factors. With poor preconstruction planning and no management, it might cease to meet your needs in less than 10 years. You can prolong the time that the pond is an enjoyable part of your life by using the building and management techniques in this handbook. If quality care begins before the dam is built, a very productive, enjoyable and relatively maintenance-free pond will be the result. Older ponds, too, can have a longer life span if proper management techniques are followed.

This is your guide to building, enjoying and prolonging the life of your pond. Use the diagnostic tools, recommendations and the additional sources whose addresses and telephone numbers are in Appendix A to create the best possible fishing water. Personnel from the Missouri Department of Conservation will gladly respond to any questions you may have about deriving the maximum enjoyment from your pond and its surroundings.

Then, on those lazy summer evenings when the day's work is done and the fish are striking at each cast, you will know that all your planning and preparation were worth the effort.



Developing a new fishing pond

The success or failure of a pond may depend upon the site you choose. Careful site selection will save construction and maintenance costs, and increase the benefits you receive from your pond. Although most potential pond sites have some features that are less than ideal, many deficiencies may be overcome with proper planning. When thinking about location, don't forget about convenience.



Remember: *A well-planned pond that is close to home and easily accessible will be used more often and provide more enjoyment than one that is far away and hard to reach. In addition, it is more likely to receive proper care.*

You also may want to consider locating your pond where it is accessible to the disabled and elderly. This may mean building a nearby parking area with a gentle slope to good fishing spots. Additional information concerning disabled accessibility is available from your local Conservation Department office.

Because moving earth is one of the biggest costs in pond building, you will want to pick an area that will keep this expense at a minimum. The most economical site is one that requires the smallest dam to impound the largest amount of water. An adequate volume of soil for dam construction must be on site or very near. An ideal location would be a natural low area or wide draw, narrowing on the downhill side.

The area to be flooded should be as flat and wide as possible to obtain the greatest water volume in relation to dam height. Ideally, more than half of the pond should be greater than 5 feet deep after filling to decrease potential aquatic vegetation problems. Most nuisance aquatic plant growth occurs in shallow water.

Creek beds or large, deep draws should not be dammed unless excess water can be diverted around the structure. Creek drainage areas often produce runoff water quantities that are too great to control except by large, expensive dams. They may require a permit from the Missouri Department of Natural Resources.



A word of caution: *Destruction of wetlands to construct a pond may be against the law. Check with the local office of the U.S. Department of Agriculture's Natural Resources Conservation Services before starting construction.*

While planning your pond, check your property deed for recorded easements for buried pipelines, power cables and overhead lines. The restrictions in these easements and their locations may alter the site you choose. Pond construction must not impact a public road or a neighbor.

Locating a pond near established wildlife cover will encourage use by birds and other animals. It is possible to develop wildlife cover and travel lanes after the pond is built, but it takes less time and effort to take advantage of what is already there.



For more information: Send for the Conservation Department's brochure "Wildlife Management for Missouri Landowners" and the aquaguide on building a pond.

Pond drainage area

The size of the drainage area or watershed is an important consideration in site selection. The drainage area includes the pond's surface area and the land above the pond that provides water from runoff.

For fish production, about 15 acres of drainage area for each surface acre of water is best. The Conservation Department recommends that the ratio of drainage area to pond surface, also called watershed ratio, ranges between 10-to-1 and 15-to-1. The exact ratio for a particular location depends upon annual precipitation, soil type and condition, the amount of and kind of vegetation covering the drainage area, and the steepness of the drainage area.

Ponds with excessive drainage areas often are not suitable for fish production. They tend to be muddy, silt in rapidly and have erosion problems in the spillway area. Runoff from normal rainfall can flush out much of the microscopic plant and animal life that fish use for food. A temporary shortage of food may result, and fish growth will be slowed. In ponds with excessive drainage areas, fish may swim out of the pond during heavy rains.

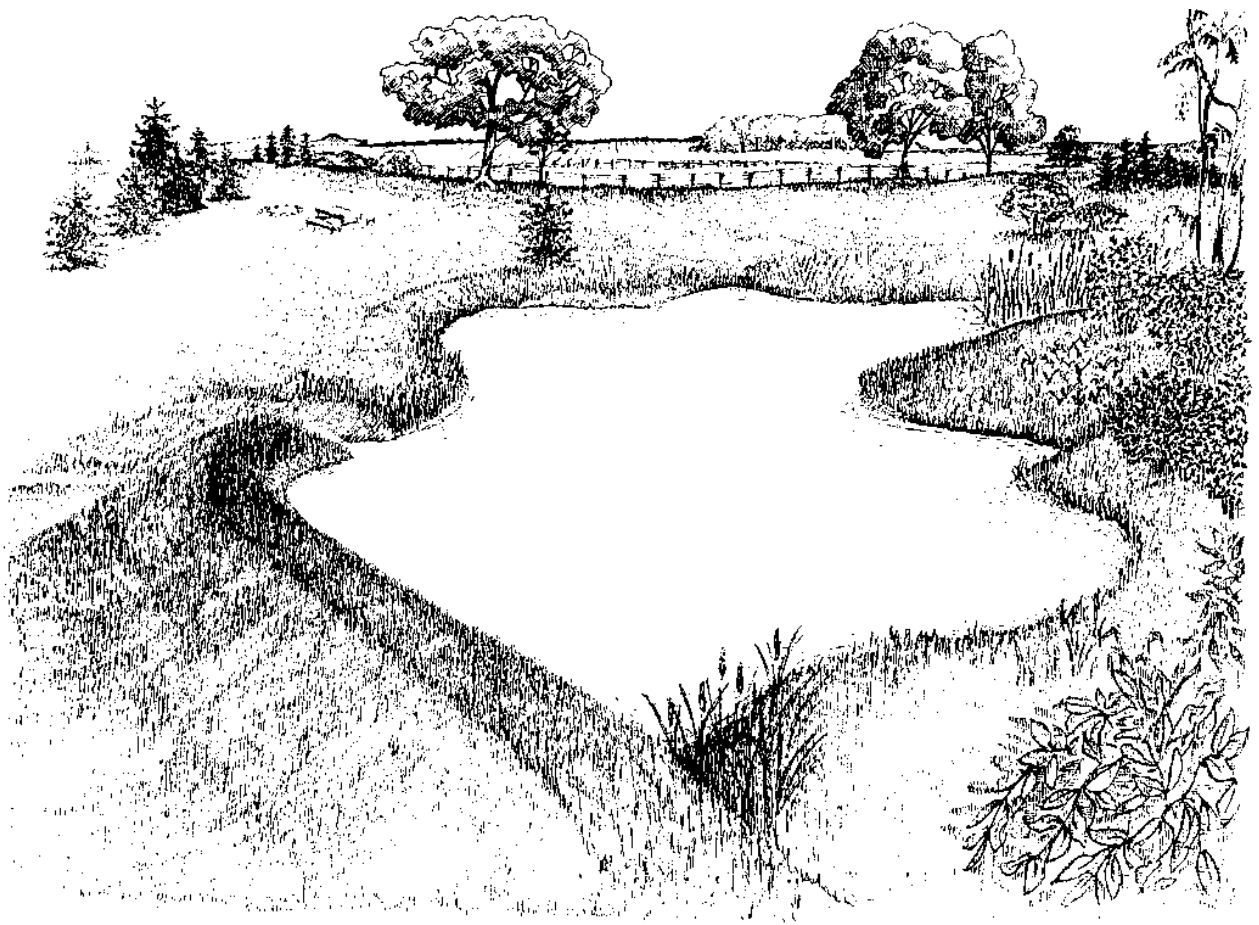
If the drainage area is too small, the water level may drop too low to support aquatic life during extended periods of hot, dry weather. Less water means less oxygen available to fish. Warm water also holds less oxygen than cold water and could result in a fish kill. Smaller water volume means decreased surface area, decreased food production in the pond and slower than normal rates of fish growth. Shallow water allows aquatic weeds to become abundant.

If the drainage area of a potential pond site is too large or too small, the effective drainage area sometimes can be adjusted through terracing. In a watershed that is too small, terracing can be used to divert water to the pond. Similarly, water can be deflected or terraced away from a pond site if the drainage area is too large.



Note: *The vegetative cover in a pond's drainage area greatly influences both the quality and quantity of water that run into the pond. Ungrazed timberland provides the cleanest water source.*

The next best cover for the drainage area would be undisturbed grassland or pasture land. Cultivated land in the drainage area contributes the poorest quality water to the pond. The silt-laden runoff from row crops and



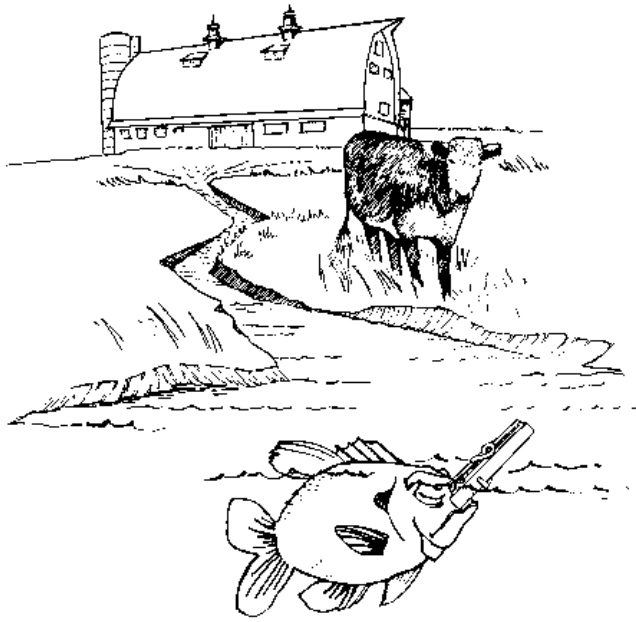
associated agricultural chemicals can shorten the life of a fishing pond, result in a fish kill, drastically reduce fish numbers or affect their rate of growth.

To avoid a muddy, unproductive pond, you should keep the percentage of cultivated land in the pond's drainage area to a minimum. Good soil conservation measures, such as terracing, minimum tillage or no-till and strip-cropping, should be in place on row-crop land before a pond is built. A minimum of 100 feet of vegetated filter strip should be maintained between the pond edge and any cultivated land.

Plant cover in the drainage area also affects the quantity and the rate of runoff a pond receives. The best situation is one where the entire drainage area is covered with thick vegetation. This slows runoff and may reduce expense in the design and construction of spillways.

The drainage area should be free of pollution sources. Ponds receiving barnyard or feedlot drainage, domestic sewage, runoff from heavily stocked or fertilized pastures or other high nutrient inputs won't support fish successfully over many years. These materials promote the growth of aquatic plants. Too much weed growth leads to a loss of dissolved oxygen as these plants die and decay. These nutrient sources also promote the excessive growth of filamentous algae, which is also known as pond scum and moss.

A healthy pond needs at least 100 feet of vegetation between it and any cultivated land.



Drainage from barnyards promotes the growth of nuisance aquatic plants and wide fluctuations of dissolved oxygen in the pond, which eventually results in unhealthy fish.

To keep your pond healthy, eliminate these sources of pollution before you begin construction. Either build a lagoon large enough to contain all the nutrients so that none can flow into the pond, or pipe the drainage from these sources to a point downstream from the pond. Chemicals used in the watershed may impact the fish in your pond. Think about potential problems before using any chemical in your pond's drainage area. Insecticides are particularly deadly to fish. Dead or contaminated fish could result from a moment of carelessness.

Water sources

Streams are usually not suitable water sources for fishing ponds. Their watersheds are generally large, which means they can carry a high inflow of silt into a pond. High flows result in muddy, unproductive water.

In addition, many stream fish are not adapted to the pond environment. They may not provide sustained good fishing and can carry parasites or disease organisms, which can impact hatchery fish when they are stocked.

Springs usually are not good sources of water for fish ponds. The area where the spring water originally enters the ground may be miles from your pond. Because you have no control over this area, you won't be able to monitor chemicals and other pollutants that are introduced into the spring.

Possible pollution isn't the only problem. Spring water may be too cool for good growth of bass, bluegill and channel catfish, and it may be too warm to successfully raise trout. The clarity, high mineral content and stable water temperature encourages the growth of excessive aquatic vegetation. A bottom withdrawal spillway can sometimes solve these problems in a spring-fed pond.

Very few ponds are actually spring-fed. Cold water near the pond bottom is a common natural pond condition not necessarily related to springs. True spring-fed ponds will have water flowing out of the pond during all but the driest of times.



For more information: *To build a spillway to use in a spring-fed pond, order the Conservation Department's aquaguide "Operating a Bottom Withdrawal Spillway."*

Types of soils and bedrock

The soil at the pond site should be deep and contain a high percentage of clay. The best soils are those that allow water to penetrate very slowly.

Examples are clay, clayey and sandy loams, and loams.

Most Missouri upland soils contain enough clay for good pond construction. A simple test for clay content is to squeeze a handful of fairly moist soil into a firm ball. If the ball does not crumble with a little handling, the soil probably contains enough clay. Consult a professional soil scientist about the material to be used in the dam construction. A good clue to the soil suitability is the success of nearby ponds.

If the soil at the potential site does not contain enough clay, it is sometimes possible to bring in clay from a nearby location to build a good dam. Contact the nearest United States Department of Agriculture's Natural Resources Conservation Service office for technical advice on the suitability of soil at the site.

Pay close attention to the soil after construction begins. If white, tan or blue clay is exposed, it should be covered with several inches of black topsoil, then mulched and seeded. These clays are easily suspended in water and will not readily settle out. This situation creates muddy water, which results in poor fish growth and a disappointing pond for the owner.



Note: As a general rule, avoid pond sites with springs or sinkholes as they may leak. Also, avoid sites in large valleys that have poorly defined stream channels and no standing water in pools.

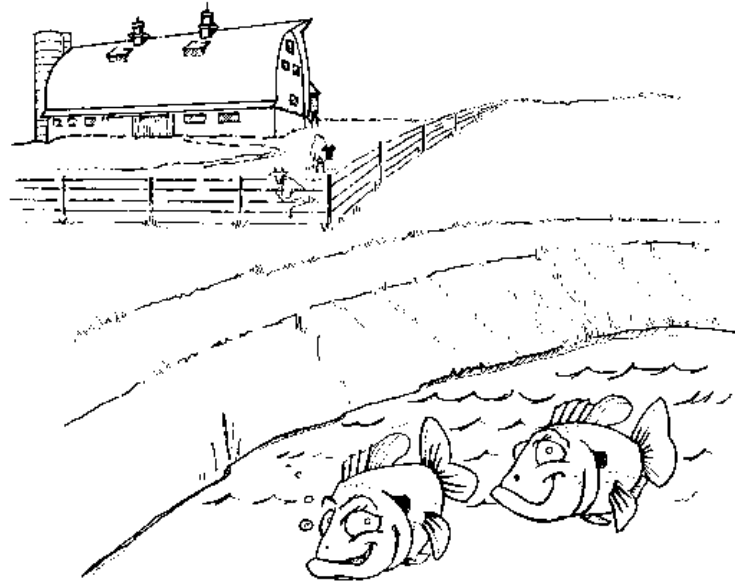
Such sites, called “losing” stream valleys, are poor candidates for successful ponds. The surface water disappears into porous bedrock.

Also avoid areas that are sandy or gravelly or that have limestone or shale outcroppings because they sometimes allow water to flow under or around the dam after construction. Rocky areas often have open cracks that are invisible above ground. These cracks in the bedrock, which feed underground springs, cause water to flow out of the pond basin. Unless properly designed and constructed, a pond built in an area of cracked bedrock may be an expensive dry hole.

Design

Fishing ponds should be designed and constructed specifically for fishing. Fish populations are easier to manage and maintain, and the recreational potential is greater in a well-designed fishing pond.

Fishing ponds may be used for a variety of other uses. It is best if all



Before constructing a pond near a barnyard, build a lagoon large enough to contain all the nutrients so that none can flow into the pond. Another option is to pipe the drainage to a point downstream from the pond.

planned uses are considered in the design stage. For example, livestock watering can seriously interfere with fish production, but it can be accommodated through proper pond design.

You will probably need some technical help in preparing your pond's construction plan. This assistance may be available from either the Natural Resources Conservation Service or the Farm Service Agency. You also may contract this work with a private engineering firm.



Tip: *Be sure your pond is built according to the plans and specifications. Many pond failures have resulted from cutting corners to save money.*

Ask an engineer or technician to help you:

- ✓ survey the pond site. Make sure you don't impound water on roads, legal easements or a neighbor's property.
- ✓ calculate the expected flow of water into the pond.
- ✓ set elevations and size for grass and pipe spillways and for the top of the dam.
- ✓ determine the dimensions of the dam and spillways.
- ✓ establish the degree of slope of the sides of the dam.
- ✓ calculate how much earthfill and other materials will be needed.
- ✓ prepare drawings.
- ✓ figure out construction procedures.
- ✓ include all intended uses in the design of the pond.

Thousands of successful ponds have been built by earth-moving contractors without formal plans, and this option is available to you. If you choose to go this route, come to a firm agreement before construction about expectations and responsibilities for correcting problems after construction is complete.

Size

Fish populations can be managed in a properly constructed pond of any size. However, larger ponds have a number of advantages. They are less susceptible to water level fluctuations than small ponds.

Smaller, shallow ponds may dry up completely in times of drought. Deeper ponds, on the other hand, may lose depth, but they will maintain enough water to sustain fish life.

Ponds less than $\frac{1}{4}$ acre can provide a lot of fishing pleasure, but they must be carefully managed. Very little harvest can be allowed because the pond supports relatively few fish. Catch-and-release fishing can work well in these small ponds.

Depth

To protect fish through periods of oxygen stress, the pond should be a minimum of 8 feet deep. Shallow ponds have less water volume, freeze earlier, are subject to winter kill and fill with sediment sooner.



Note: Ponds that have less than 8 foot of water when full are not eligible for stocking with fish from the Missouri Department of Conservation.

Shallow water around the pond's edge invites the growth of aquatic plants. To help prevent some common aquatic vegetation problems, grade some of the edges of the pond to a 3:1 (horizontal to vertical ratio) slope to a water depth of at least 3 to 4 feet. This may not eliminate all aquatic plant problems, but it will ensure that problems will not start as soon or be as severe. Although grading the shoreline may be an added cost, it should be balanced against the future cost of aquatic plant control.

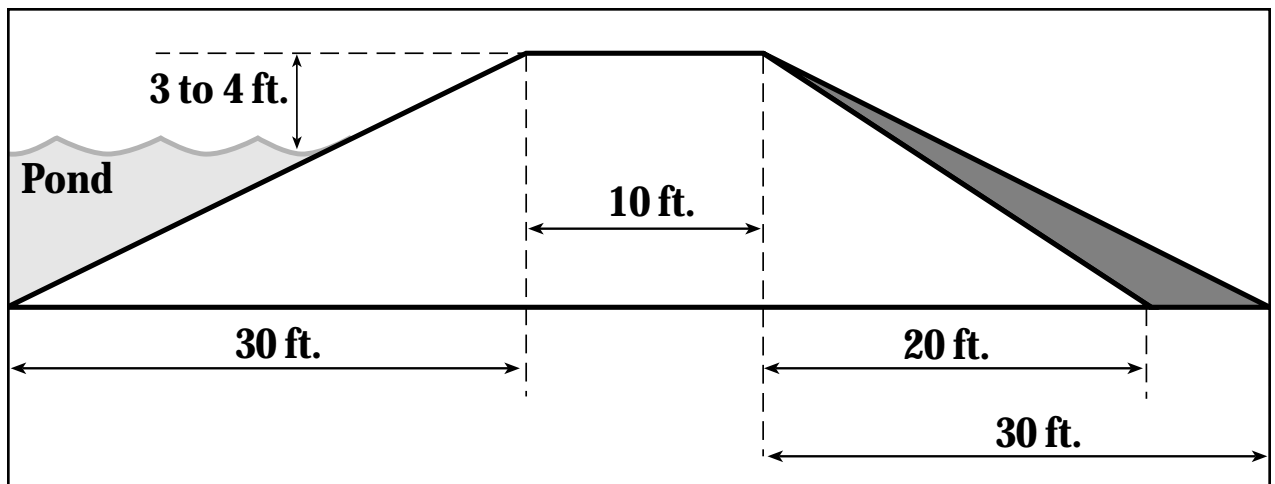
Deeper water does not mean more fish in your pond. Because fish production is based on the microscopic plant growth in the upper 3 to 5 feet of water, depths greater than 15 feet are not necessary in a fishing pond. However, the greater depth will extend the usable life of the pond and provide more total oxygen for fish than a shallower pond of the same surface area. The pond may need to be deeper to accommodate other uses.

Dam

A dam less than 20 feet high should be at least 10 feet wide across the top. The top width should be increased by 2 feet for each 5 feet of dam height over 20 feet. This width provides a roadway and minimizes the danger of dam failure caused by muskrat damage.

The front slope on the water side should be 3:1, and the back slope should be 2:1 to 3:1. These figures mean that the front slope of the dam will be 3 foot wide for each foot of dam height, and the back slope will be 2 or 3 foot

Using the correct dimensions when building a dam will minimize muskrat damage and reduce maintenance.



wide for each foot of dam height. A 3:1 slope is much easier and safer to mow than a 2:1 slope, but it will increase construction costs.

Each foot of dam height will add 5 feet of width to dams that have slopes of 3:1 in the front and 2:1 in the back, while 3:1 slopes front and back will require 6 feet of width for each foot of dam height.

Dam freeboard

The freeboard is the distance between the planned water level, or spillway level of the pond, and the top of the dam. It should be at least 3 feet, but it may need to be bigger if the drainage area is large. Three feet is usually the minimum freeboard necessary to keep water from topping the dam during runoff after a heavy rain and to minimize damage from muskrat dens.

Musk rats sometimes burrow into the dam to create an underwater entrance for the den, which has a living space above the water level. If the water level rises and remains high, the muskrat will burrow upward and construct a new dry den closer to the soil surface. It may pierce the surface or be so close that the den caves in easily. This damage to the den encourages muskrats to dig further into the dam.

These holes may eventually cause the dam to fail by providing a pathway for water to flow and cause erosion. An adequate freeboard usually eliminates leakage or dam failure due to muskrat burrowing.



Remember: *To keep muskrats away from the dam, construct steeper slopes on the natural pond banks. Because these rodents prefer to live in the steeper slopes, they may leave the dam alone.*

Spillway

Spillway design is based on a complex set of calculations using several variables. Because of its complexity, it's important to get technical help. Contact the Natural Resources Conservation Service or a private engineer. Many contractors also are qualified to help with spillway design.

Construction

All topsoil should be removed from the dam site and borrow area and stockpiled for later use. All vegetation, roots, stumps and large rocks should be removed from the dam site. If they aren't, the decay of organic materials will cause passages that allow water to seep through the base of the dam. Large rocks may prevent the soil from being properly compacted, which also could result in seepage.

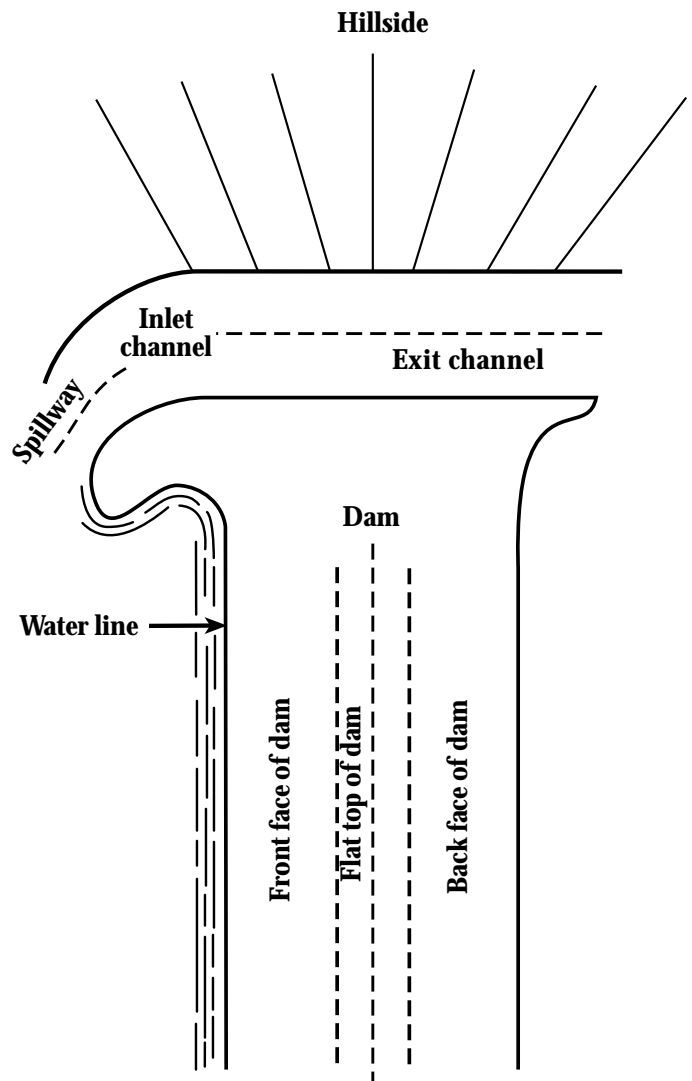


Tip: *All material used in the dam must be well compacted by either a sheepsfoot roller or earthmover with rubber tires. Loosely compacted dams may fail.*

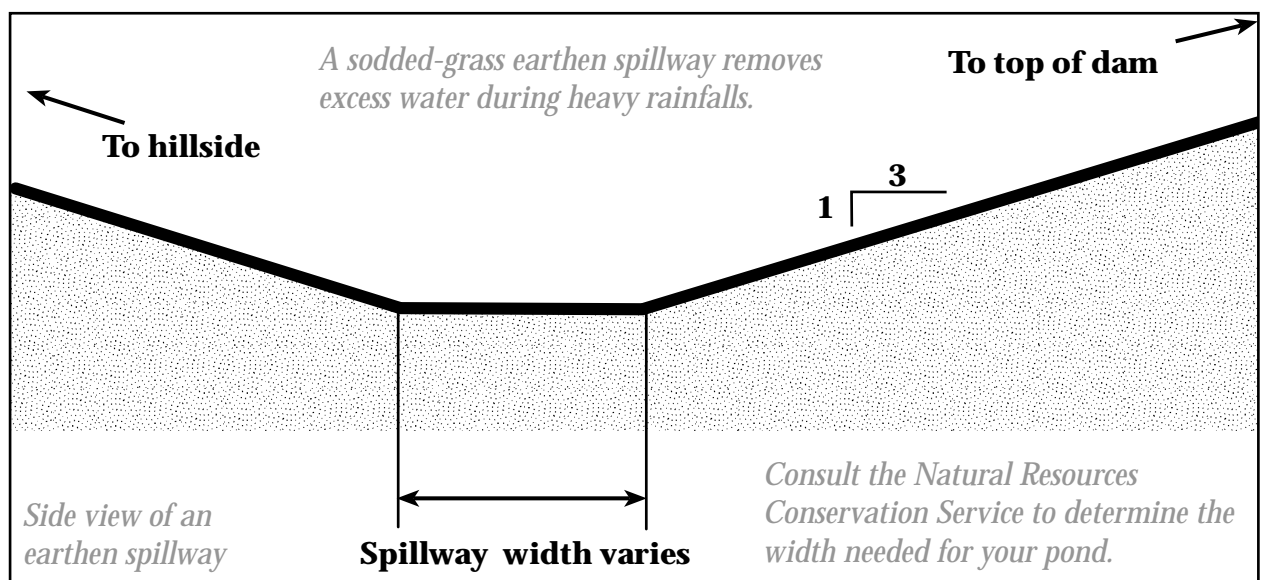
A core trench should be dug along the length of the dam's centerline. This trench should be deep enough so that all soil, sand, gravel and loose rock is removed down to either solid rock or good clay. The trench should extend a minimum of 3 feet into impervious subsoil or be anchored into solid rock the length of the dam and into the valley walls at either end of the dam. It should have a minimum base width of 8 feet.

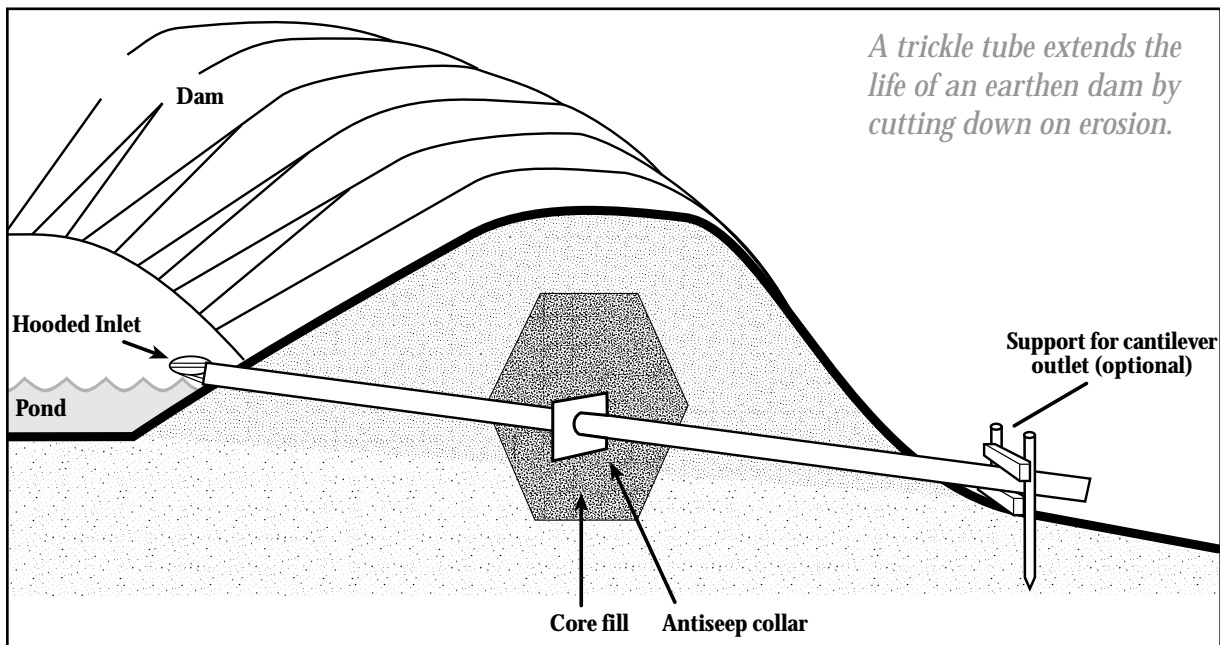
The core trench should be filled with the best available clay, which should be well compacted from the bottom of the trench up through the dam. If this clay core wall extends above the expected water level, it will resist seepage and prevent significant water loss through the dam. Many ponds leak because the core trench and wall were not constructed properly.

Almost all ponds are built to include a sodded-grass earthen spillway, which will help remove excess water during heavy rainfalls. The bottom of the spillway channel should be 3 to 4 feet below the lowest point of the top of the dam and wide enough to carry expected runoff water in a thin sheet to a point below the dam.



Top view of dam with an earthen spillway

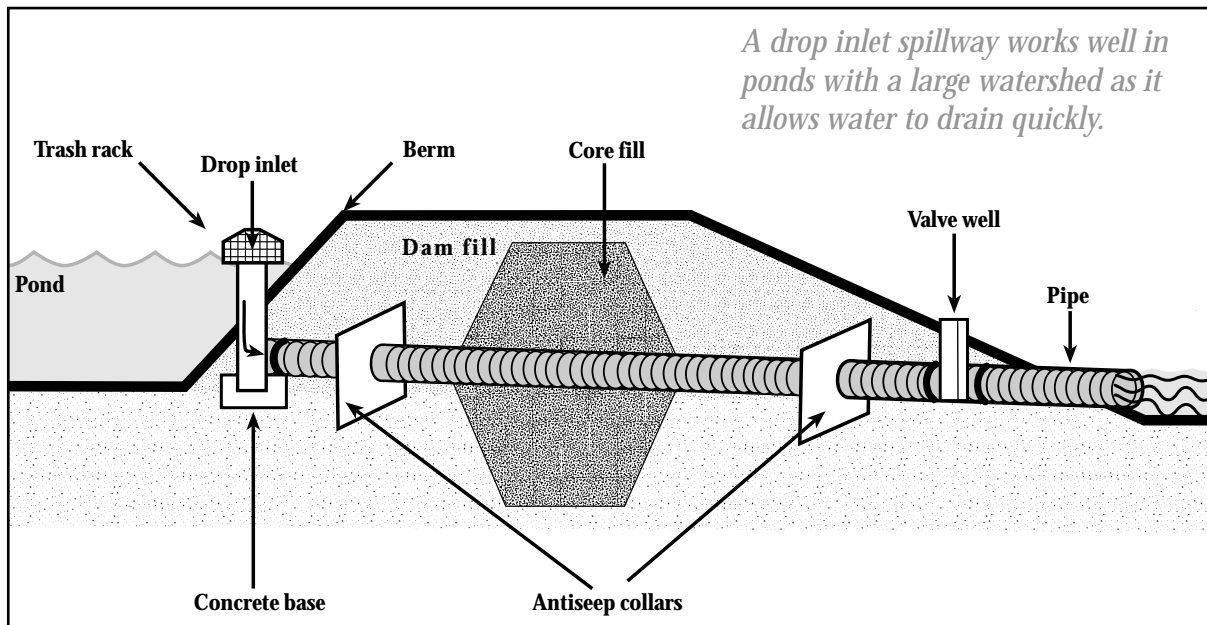


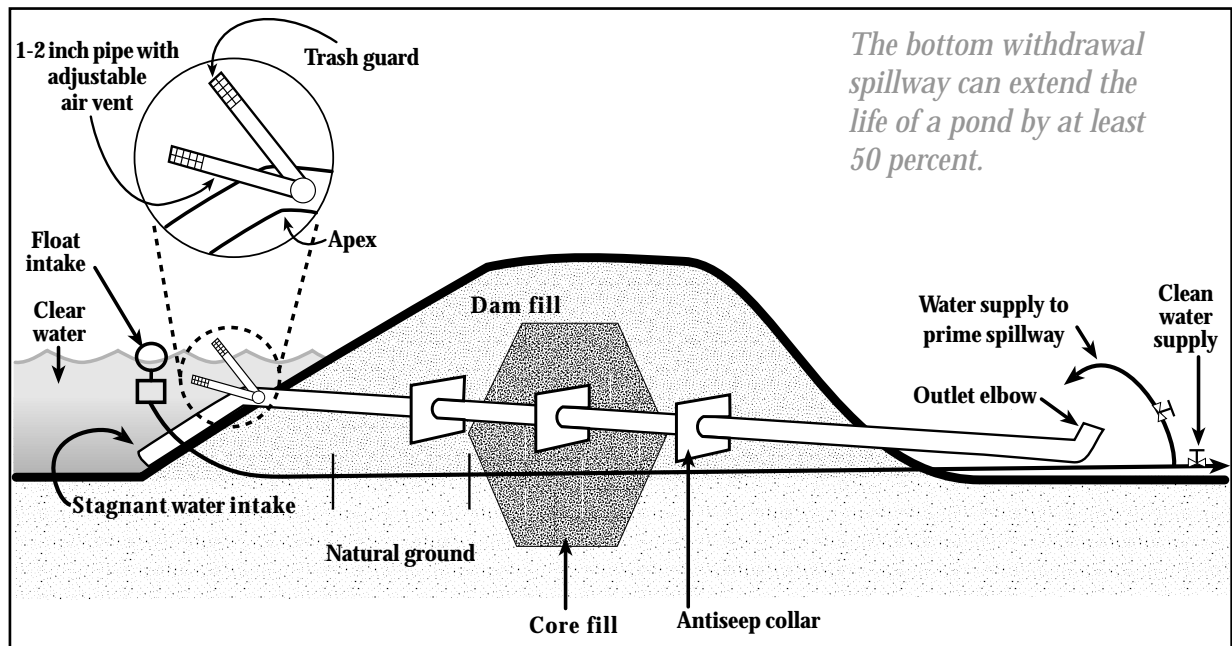


The width of the spillway is determined by a complex set of calculations that takes into consideration local rainfall duration and intensity, the slope of the watershed and the type of ground cover anticipated in the spillway. Consult with the Natural Resources Conservation Service to determine the size of your spillway.

A second type of spillway is a trickle tube, used in combination with earthen spillways. This tube is installed during construction with the upper opening at the planned water level. The lower opening should be at or near normal ground level at the back of the dam. See illustration above.

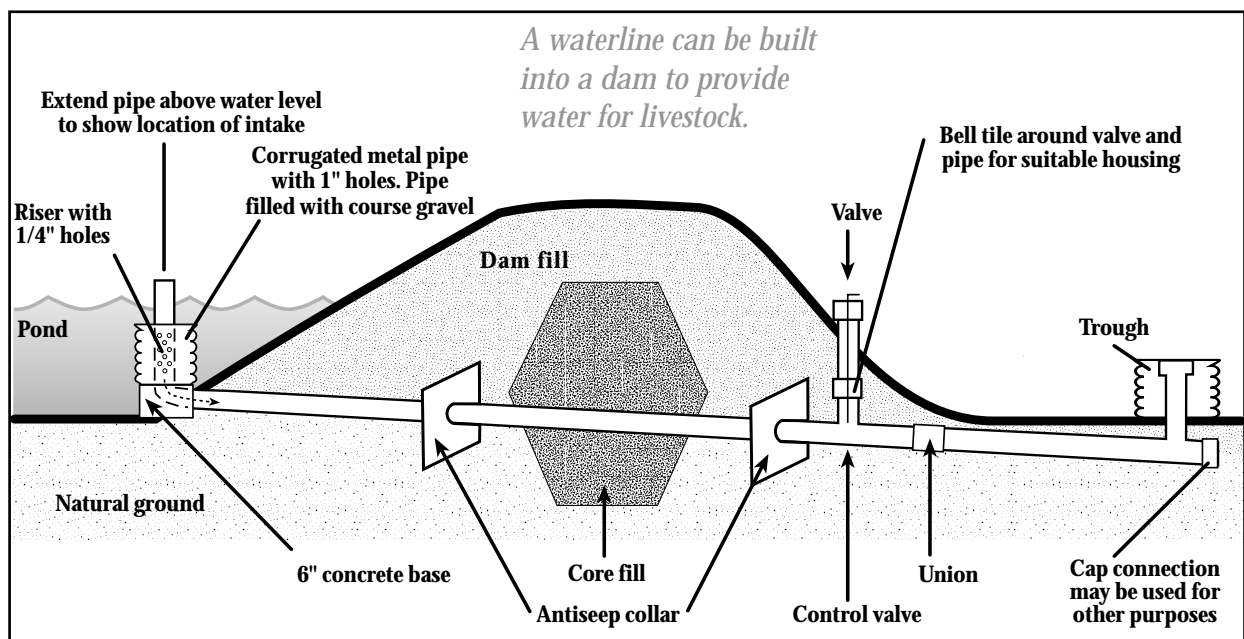
The upper tube opening, which determines the water level, is generally set





12 inches below the earthen spillway level to keep water from flowing across the earthen spillway. Constant water flow over the earthen spillway will leave it moist and vulnerable to severe erosion during heavy rains. The trickle tube should be large enough to carry most runoff, or just large enough to draw the water level down in a short period of time after water quits flowing in the pond.

The drop inlet structure, as shown at the bottom of page 14, is another type of spillway used in combination with an earthen spillway. It allows water to trickle over the rim of an open, vertical pipe with the rim set at the desired water level. Water is then drained from the drop structure through a



horizontal pipe through the dam.

If you think you might want to drain your pond, install a spillway that has a drain tube near the bottom of the dam. An accessible valve installed on the tube below frost line in the earthen toe at the back of the dam will allow you to control the water level.

An optional watering line may be installed along with the drain tube below the dam to provide water for livestock. The line could be tapped off the drain tube just upstream of the valve. A second valve can be installed to control water flow to a watering tank. See bottom illustration on page 15.

Another type of spillway is the bottom withdrawal spillway, which discharges water from the bottom of the pond. This device is designed to carry much of the incoming muddy runoff water and some of the incoming sediment and organic debris through the pond and downstream without raising the water level to the earthen spillway level. This will improve the productivity of the pond and extend the usable life of the pond at least 50 percent. Used as a drawdown structure, this spillway's siphon capabilities can take the place of the drain tube. See top illustration on page 15.



For more information: *Send for a copy of Conservation Department's aquaguide "Operating a Bottom Withdrawal Spillway."*

Any tube or pipe through the dam requires the installation of anti-seep collars and thorough soil compaction to prevent water from leaking along the pipe and possibly undermining the dam.



Tip: *Do your fish a favor. Leave some trees and brush piles in the pond basin to provide cover for the fish. These spots also enhance the production of aquatic insects that fish eat.*

Although it may be necessary to remove most vegetation to get soil for dam construction, any brush and trees that are left in water less than 12 feet deep will improve your pond for fishing.

Before the pond fills, build two 10-foot diameter brush piles per acre of surface water or leave their equivalent in standing brush. Two more brush piles per acre should be added at three- to five-year intervals after the pond fills. These brush piles should be in water no deeper than 8 to 12 feet and should extend above the water surface so anglers can find them. Be careful not to add too much brush too quickly. Too much organic material added to the pond can cause water quality problems.



For more information: *Send for the Conservation Department's aquaguide "Fishing in a Barrel" for more details on fish cover and attractors.*

You may want to remove trees and brush from areas that are planned for swimming and wading. The material from these areas may be used for brush piles or moved to the upper end of the pond to act as silt and debris traps to help keep the incoming water cleaner.

Excavate materials for dam construction from below the planned

waterline in the basin or from outside the pond basin to keep the pond area attractive. If the soil in the basin is a thin layer, it should be left in place to maintain the pond's water holding capabilities.

If it can be done without breaking the natural water-tight soil seal in the bottom of the pond, dropoffs, islands and trenches should be left or constructed in the pond. These changes in bottom elevation create a variety of habitat for aquatic species.

When construction is complete, spread the stockpiled topsoil over the dam and spillway areas to encourage the growth of ground cover.

To provide a grassy bank for fishing in areas accessible to anglers, clear trees and brush from a strip 20 to 30 feet wide along the water's edge. However, several trees should be left to provide shade for anglers and to cool the water. If your pond is to be built in a wooded area, a fence of small mesh wire should be constructed parallel and as close to the shoreline as practical. This fence will trap falling and blowing leaves that would otherwise enter the water. The decay of large quantities of leaves releases tannic acid, which will cause the pond water to have a brown or black stained appearance. Besides being unsightly, this stain keeps sunlight from the pond that is necessary for fish growth.



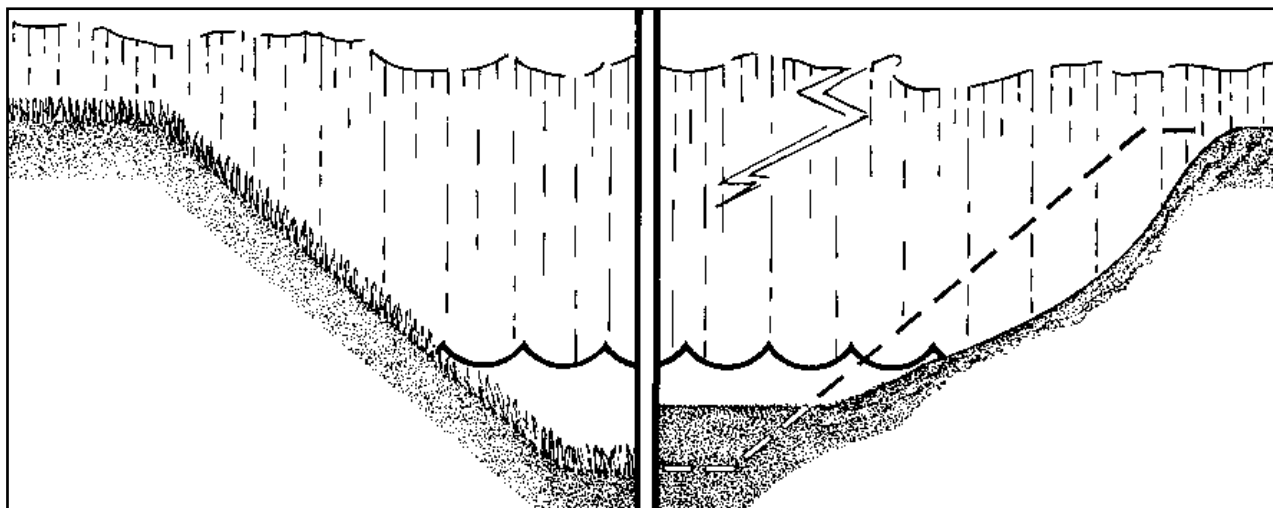
Remember: *Don't disturb wooded draws leading into the pond area. They provide travel lanes for wildlife and help keep silt out of the pond.*

Brush piles constructed in and along these draws will be used by rabbits and other wildlife. The vegetation also will slow runoff and trap silt.

Plant grass as soon as possible in the pond basin to prevent the sides from eroding as the pond fills for the first time.

Post construction

As soon as the pond is finished, the same day if possible, all raw areas including the pond basin, dam, spillway and banks should be limed and fertilized to soil-test specifications, then seeded and mulched. Soil can be



tested by sending a sample to the Natural Resources Conservation Service. Be sure to allow plenty of time to get your sample tested before you need to plant.

Rain falling on bare or disturbed soil can wash large amounts of silt to the pond bottom. If the pond does not completely fill immediately, wave action and water level fluctuations on the bare soil in the basin can move a lot of silt to the bottom of your new pond.



A word of warning: *A new unfilled pond can lose a significant part of its depth in only one rainfall from erosion of unprotected soil.*

The Natural Resources Conservation Service or the local University of Missouri Extension Center can help you choose an appropriate seed or sod, or you can follow the general recommendations below. Ask about the use of warm-season grass mixtures because of their value as wildlife habitat as well as soil protection.

For the pond basin, recommended cover crops by season are:

- ✓ spring or early summer – oats, 75 pounds an acre
- ✓ mid-summer – Sudan grass, 25 pounds an acre
- ✓ late summer or fall – rye or wheat, 100 pounds an acre.

After seeding and mulching, fertilize to soil-test specifications. If possible, the cover crop in the pond basin should be mowed if it grows more than 6 inches high before it is covered with water. As the vegetation decays underwater, it helps clear the water and promotes the growth of fish food organisms. Too much decaying green vegetation, however, can adversely affect water quality.

A dense sod is protection enough for pond dams that are not exposed to strong winds. One of the best grasses for this purpose is fescue. Check with the nearest University of Missouri Extension Center for recommendations for your area.

If the threat of wave damage is serious, the dam can be protected with large “shot” rock, placed in a continuous layer at least a foot thick from a minimum of 2 feet below to 1 foot above the planned water level. Any rock you wish to place deeper on the dam will provide excellent habitat for crayfish and fish, as well as added bank protection.



Remember: *A thick grass sod in the spillway is extremely important. Fescue makes a good, quick cover crop in the spillway, but you may want to follow the recommendations for basins listed above.*

Protect banks by planting Reed’s canary grass or wild or Japanese millet in a strip around the shoreline. If the pond is full, the millet should be sown on any bare soil down to the water’s edge. If the pond is not full, sow seed far enough down that a strip of millet will be covered when the pond fills.

If land in the watershed is row cropped, a strip of sod should be left or

established between it and the pond. A 100-foot-wide strip of permanent grass cover is usually considered a minimum buffer zone. This grassy area acts as a filter between the pond and the cultivated soil. If you choose a warm-season grass such as switch grass, not only will you protect your bank, but you also will be providing excellent cover and habitat for wildlife.

Landscaping and habitat development

Windbreaks planted near the pond, usually along the south and west shorelines, can reduce wave action and turbidity and provide wildlife cover. The proper species to plant will vary across the state, but a two-row planting of cottonwood or poplar and red cedar will offer wind protection within five to seven years. Consult the Conservation Department to order trees or the University of Missouri Extension Center for more information on appropriate species to plant in your area.



Tip: *One of the most effective things you can do to keep the water clean and to improve the wildlife habitat around your pond is to fence out livestock.*

Some chemicals used to treat aquatic vegetation require that livestock be kept from the treated water for a period of time. Keep livestock that have been sprayed with pesticides from wading in the pond because the chemicals can pollute the water and sometimes cause a fish kill. The Conservation Department recommends that livestock be watered from a tank below the dam. Consult the Natural Resources Conservation Service for information. If you must use the pond for livestock watering, provide a fenced lane to one or two watering points.

Maintaining your pond

Regular maintenance of your pond will reduce expensive repairs and the chance of dam failure. It is certainly easier to clean debris from an overflow pipe than to rebuild a dam.

The following maintenance tips will help extend the life of your pond:

- ✓ Keep the entire dam clear of trees and bushes. Tree roots will eventually decay and allow seepage through the dam. The cover created by trees and bushes attracts burrowing animals.
- ✓ Keep the grass on the dam and spillway in good condition by fertilizing according to soil-test results. Control weeds and brush by mowing.
- ✓ Discourage burrowing animals by mowing the dam as often as you do your lawn. Because muskrats sometimes burrow to gather roots, short

grass will discourage growth of the type of plants they like to eat. Also, you can detect and repair damage before it becomes a serious problem.

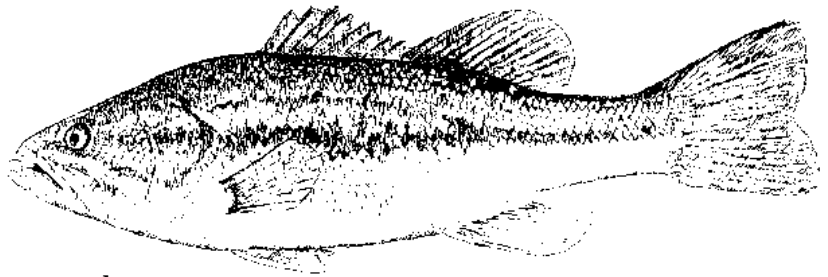
- ✓ Control burrowing animals near ponds as necessary. They can do a great deal of damage to dams and earth spillways. Consult your local conservation agent for appropriate control methods.
- ✓ After heavy rains, inspect the dam carefully for eroded areas. If small gullies have formed, fill them with good soil, compact it well, re-seed and mulch.
- ✓ Check the pond side of the dam frequently for damage from wave action. If significant damage is occurring, protect the dam with rock riprap. You also may want to add riprap to other banks that are starting to erode.
- ✓ Make sure that pipe spillways, valves and the area around watering tanks are clear and free of trash.
- ✓ Keep fences around the pond in good repair.
- ✓ Pull all cattails at two- to three-week intervals. Never allow them to produce seeds. A single cattail in the spring may expand to an area 10 feet square by the fall. Maintaining even a small stand of cattails involves diligently removing all seed heads before they produce seeds and pulling all sprouts outside the maintained area.
- ✓ Remove snow from an ice-covered pond if the snow cover persists more than two weeks. To allow sunlight to penetrate effectively, remove snow from at least 25 percent of the pond in strips or squares. This allows the underwater plants to continue to produce oxygen. Check the ice thickness for safety before venturing out on it.

Managing a new fishing pond

A proven fish stocking combination that provides both food and good sport-fishing in your pond is largemouth bass, bluegill and channel catfish. Properly managed, this group of species provides great fishing and good eating.

Largemouth bass

This predator species, easily recognized by their large mouth and dark stripe or blotches down the side, have been stocked in thousands of Missouri ponds. Because of their growth potential and fighting ability, bass are preferred by many anglers. Largemouth bass are well adapted to ponds and reproduce readily in the pond environment.



Bass eat a variety of foods. Fish and aquatic insects make up most of their diet. Bass also eat frogs and crayfish when available. Less frequently, they will eat other animal life, such as mice, moles, snakes, leeches and baby ducklings.

Young bass grow rapidly when food is plentiful. In ponds with good growth conditions, they may reach a length of 3 to 5 inches their first summer, and from 12 to 15 inches after three years. Largemouth bass, like many other fish, grow faster in the southern part of the state where the growing season is longer, but a lack of soil fertility in some areas may neutralize that advantage. Largemouth bass usually live six to 10 years, but some have lived as long as 12 to 15 years. Many largemouth bass larger than 8 pounds have been taken from Missouri ponds.



Important tip for anglers: *Many of the record- or near record-sized fish caught in Missouri and other states are taken from ponds.*

Largemouth bass in Missouri ponds usually reach spawning size at 10 to 12 inches. The males fan a depression in shallow water with their body and fins, then entice females over the nest where they deposit eggs that the male fertilizes. Nesting begins when the water temperature reaches 60 to 65 degrees Fahrenheit. Approximately 2,000 to 7,000 eggs are produced per pound of fish. The male guards the eggs during the eight to 10 days required for hatching.

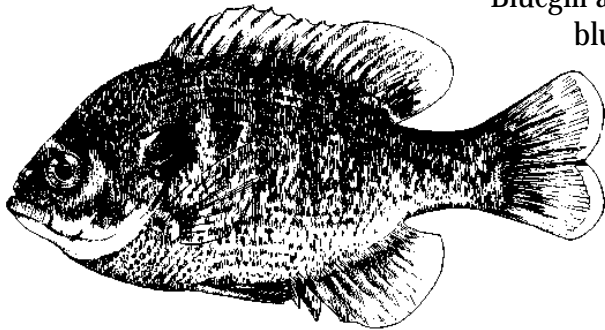
If harvest is carefully regulated, largemouth bass maintain their

population without having to be restocked.

Because the largemouth bass is a predator species and reaches a relatively large size, adequate prey fish must be available for this species to reach its growth potential. Stocked alone, bass usually overpopulate and do not grow well.

Bluegill

A fine sport and prey fish, bluegill are well adapted to pond life and particularly suited for stocking in combination with largemouth bass. Bluegill serve as a food source for bass, provide many angling opportunities and are great eating. While bass harvest needs to be on the conservative side, bluegill are generally more abundant and provide more pounds of fish that can be harvested.



Bluegill are easily identified by their relatively short head, blunt nose, small mouth, blue lower gill cover, an entirely black ear flap and an irregular blackish spot at the base of the top, soft, dorsal fin. Superficially, they look like several other members of the sunfish family and have been called by many names including sunfish, perch, pond perch, bream and brim. This fish feels rough to the touch in comparison to the green sunfish, which feels slick.

Food of young bluegill include microscopic plants and animals. As bluegill increase in size, their food preferences gradually change to aquatic insects, snails, small crayfish and an occasional small fish. Adult bluegill feed mainly on aquatic insects. Terrestrial insects are eaten when available. Few Missouri bluegill are caught that exceed a pound, but they have been known to exceed 12 inches in length and weigh more than a pound.

Growth is dependent upon the amount of food available, water temperature and the number of fish in the pond. It takes about three growing seasons to produce a keeper bluegill. The average life span is about five years, but they can live eight to 10 years. When overabundant, they seldom live more than four to five years and may never exceed 5 inches in length.

In Missouri, bluegill spawn from May to August. They are frequently sexually mature in their second year of life, or when they are about three inches long. The male constructs the nest, a saucer-shaped depression, when the water temperature reaches 70 to 75 degrees Fahrenheit. The eggs are deposited by the female and fertilized by the male who guards the nest. A 4-ounce female may deposit 12,000 eggs while larger females may deposit up to 50,000. The eggs hatch in two to five days, depending upon water temperature. Spawning beds consist of many nests close together. These locations can provide excellent fishing during the spawning season. Bluegill rarely need to be restocked in ponds.

Channel catfish

A favorite fish of many anglers, channel catfish do well in ponds and provide additional angling pleasure when stocked in combination with largemouth bass and bluegill.

Channel catfish eat a wide variety of foods ranging from fish to insects to aquatic plants. Fish appear in the diet when catfish reach 12 to 14 inches long. Channel catfish do not play a significant fish predator role in Missouri ponds. Fish eaten are generally dead or injured. Small catfish feed mostly on aquatic insect larvae, crayfish and filamentous algae.

Fingerling channel catfish less than a year old that are stocked in a new pond in the fall can be 11 to 12 inches long the following year, 14 to 15 inches long after two years, and 16 to 18 inches long after three years. Channel catfish may live to be 12 to 15 years old, but six to 10 years is more common.

Channel catfish can and do reproduce in ponds. Spawning usually takes place in a dark cave-like hole. Examples are hollow logs and beaver or muskrat holes enlarged by the male. The fish also use tile and other artificial structures. Spawning in Missouri takes place from late May to late July. Prime spawning temperature is about 80 degrees Fahrenheit. One- to 4-pound females produce about 4,000 eggs per pound of body weight while larger fish produce about 3,000 eggs per pound of body weight.

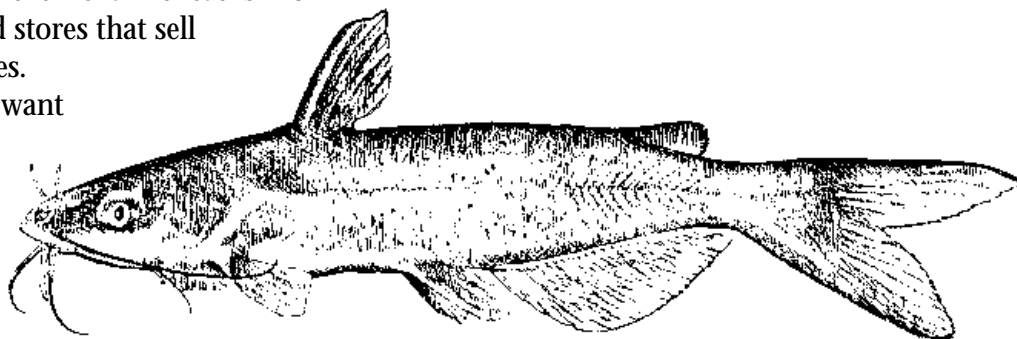
In clear ponds, bass and bluegill usually eat most of the eggs and young. If this were not the case, the pond would soon be overrun with small catfish that could not obtain enough food to grow. Because survival of young channel catfish is poor in ponds stocked with bass and bluegill, restocking is eventually necessary to maintain the catfish population.



Tip: *Adult bass can eat channel catfish less than 8 inches in length, so you should stock channel catfish that are larger than 8 inches.*

For good growth, up to 20 per acre of 8-inch or larger catfish may be stocked per year. Unless you supply supplemental food, avoid building population levels greater than 60 or 70 channel catfish per acre. For best results, keep good records of those stocked and those caught and removed. Channel catfish are available from commercial hatcheries in Missouri. A list of fish dealers is available from any Conservation Department office. Many pond owners purchase their channel catfish for restocking at local feed stores that sell fish on designated dates.

Some pond owners want to stock only channel catfish. When channel catfish are stocked alone and are allowed to grow



to adult size, reproduction and survival rates can be so high that crowding and slow growth result. In this situation, all adults should be harvested before they reach 15 inches. Otherwise, there soon may be too many catfish in the pond for the available food. Slow growth and muddy water will result.

Too many large channel catfish in the pond may lead to a fish kill due to a lack of sufficient oxygen. You must harvest these fish as they get larger.



For more information: Order the Conservation Department's aquaguides "*Raising Catfish for Food and Fun*" and "*Monoculture of Channel Catfish in Farm Ponds.*"

Fathead minnow

This minnow species is often stocked in new ponds before other species. Fatheads grow to about 3 inches maximum. They seldom live beyond three years.

Eggs are deposited on the underside of objects, such as tree trunks, branches, aquatic vegetation or boards placed in the water for that purpose. Because they reproduce several times through the summer, they provide large numbers of very small fish that feed the fish that are stocked later.

The minnows promote good early growth of the bass, which encourages desirable early reproduction. Because they do not grow large enough to escape bass predation, the minnows will generally disappear from the pond in a year or two.



For more information: To discover how minnows can help your pond, send for the Conservation Department's aquaguide "*Fathead Minnows in New Ponds and Lakes.*"

Other species

Almost any freshwater fish species will live and grow in ponds. Some of these species can add to the enjoyment derived from a pond, and some will create problems. Some of these species are discussed below.

Redear sunfish

This sunfish can grow to 12 inches in length. They reproduce poorly in ponds when competing with bass and bluegill, but generally will maintain a low density population.

They feed on small snails, clams, crayfish and other animals, and may help to control populations of snails, which are a required host in the life cycle of the yellow and black grub.



For more information: To find out how redear sunfish can help control grubs, order a copy of the Conservation Department's aquaguide on fish parasites.

If you want to stock redear in a new or renovated pond, replace $\frac{1}{4}$ of the recommended number of bluegill fingerlings with 1- to 2-inch redear in a new pond. If stocking into an established bass population, you will need 75 redear that are 4 inches or larger per acre.

Hybrid sunfish

Hybrid sunfish are an artificial cross between two sunfish species, generally the green sunfish and the bluegill. These hybrids grow larger and more rapidly than regular bluegill, but the difference is slight without artificial feeding. Since they are somewhat more aggressive in their feeding habits, hybrid sunfish are easier to catch than other sunfish. Because they will not produce enough offspring to allow bass to grow at normal rates, hybrid sunfish should not be stocked alone with bass. Without artificial feeding, you may stock up to 100 hybrids per acre to replace a similar quantity of bluegill. With feeding, replace up to 200 bluegill per acre with hybrids. When you have a pond with existing bass populations, stock hybrids that are at least 4 inches in length at a rate of up to 75 per acre.

Grass carp

Grass carp are an Asian fish brought to this country because they eat aquatic vegetation. They are commonly stocked to control excess vegetative growth and are available from commercial dealers. They will not reproduce in ponds or lakes, but will live up to 10 years and reach weights of 30 to 60 pounds. Average stocking rates to control most rooted vegetation are from three to five 8-inch or larger fish per acre of vegetation. This species is normally stocked after problem vegetation is apparent.



For more information: *To learn more about controlling pond vegetation, order the Department's aquaguide "Grass Carp Control Weeds in Ponds and Lakes."*

Crappie

Although crappie are valuable sport fish in larger bodies of water, they seldom provide an acceptable harvest in ponds. They prey on small fish and compete with adult bass for food. Crappie spawn several weeks earlier than bass and bluegill, so the newly hatched crappie have a head start in the competition for food needed by all later hatched fish. When crappie are stocked in ponds usually one of two conditions develop. A few stocked fish live and grow to a very large size with limited reproduction; or, much more commonly, they reproduce and the young survive in great numbers. Soon the pond becomes overpopulated with small, slow-growing crappie that are of an unacceptable size. For these reasons, they are not recommended for lakes smaller than 100 acres.



A word of warning: *Consult your local Conservation Department office for advice before stocking crappie.*

Bullheads

Bullheads, a member of the catfish family, have an almost square tail fin while the channel catfish's tail fin is deeply forked. Bullheads, often called mud cats, are not recommended for pond stocking because their bottom feeding activity may cause a pond to become muddy. This handicaps the sight-feeding bass and reduces food production. When stocked alone, bullheads overpopulate. In clear ponds with a good bass population, few bullheads will survive; but the ones that do will grow to a large size, are fun to catch and provide good eating.

Common carp

Common carp are not recommended for stocking in ponds. These bottom feeders tend to overpopulate and grow slowly. Like bullheads, their feeding activity tends to muddy the water.

Green sunfish

This species, frequently called pond perch, creek perch or black perch, is often found in ponds that have not yet been stocked with largemouth bass and bluegill.

This sunfish is often confused with bluegill. The green sunfish has a much larger mouth, the ear flap is black with a whitish or yellowish margin and the body feels slick to the touch. Stocking this species in ponds is not recommended.

If green sunfish are present before stocking and are large enough to be a predator, they can present a serious threat to the small bass, bluegill and channel catfish that are stocked later.



Caution: *If green sunfish are allowed to spawn before the bass and bluegill are stocked, severe overpopulation and food competition may occur. The pond may never produce good fishing.*

Green sunfish have been used experimentally as a substitute for bluegill in combination with largemouth bass. The green sunfish provided some food for the bass but not enough for good bass growth, and they compete with the bass for many food items.

This species is often stocked by pond owners by mistake when they get their fish from creeks or other ponds. Green sunfish will eventually find their way into many ponds. They do not pose a serious problem if the bass population is already present and well managed.

Other fish

While many other species have been stocked in ponds, most have met with limited success. Northern pike, walleye, trout and stream fish of several species have all been tried but usually fail in some way to produce good, sustained fishing without extra and diligent management effort.

A common problem with most of these fishes has been their failure to reproduce and maintain the population. If reproduction does occur, there may not be enough food to support desirable populations with adequate growth. None of these species are recommended for stocking ponds.

How to stock

Many years of study went into determining the recommended stocking rates for Missouri ponds. These rates allow good fish growth and provide enough fish to enable you to keep some without hurting your pond's future fishing. Good fishing depends on stocking your pond correctly.

The Conservation Department recommends that the maximum number of largemouth bass, bluegill and channel catfish when stocked in combination be 100 bass, 500 bluegill and 100 channel catfish fingerlings per surface acre.

Stocking at lower densities is recommended in some counties due to a lack of adequate soil fertility. Stocking at higher densities usually results in slow growth and poor fish populations of all species.



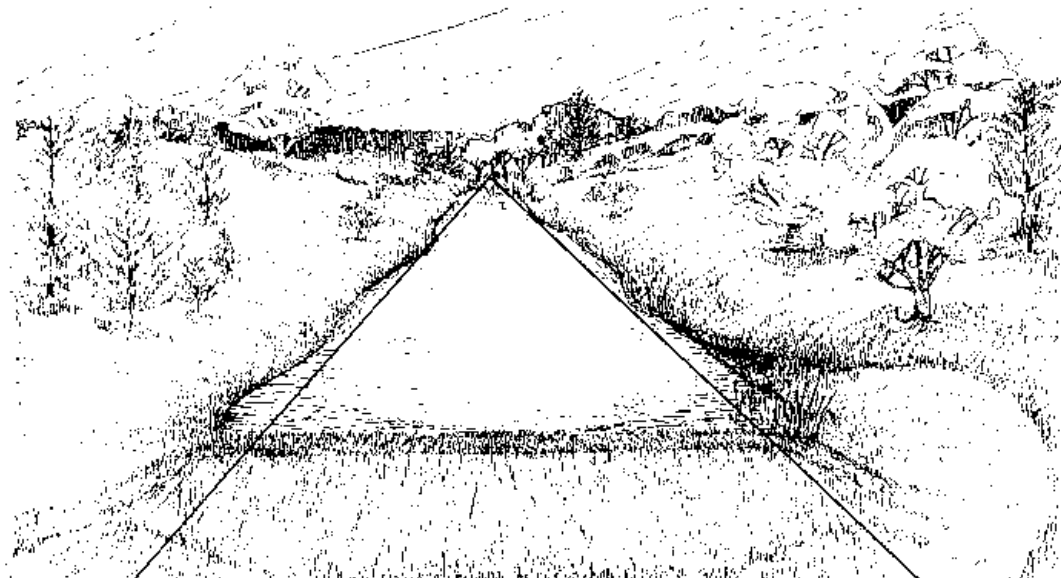
For more detailed information: *To find out the recommended stocking rates for your area, contact any Conservation Department office.*

Many years of study have shown that stocking small fish – rather than adults – at recommended rates and ratios increases your chances for desirable fish populations and better fishing. It may take a little longer for the pond to produce “keepers,” but the results are more predictable and more satisfying in the long run.

Many pond owners express reluctance to stock bluegill because of their tendency to overpopulate. This problem is a direct result of overharvest of bass. If bass numbers are maintained, bluegill numbers seldom are a problem. In fact, bluegill are absolutely necessary for optimum bass growth.

Estimating pond size

You must know the size of your pond so you can determine the proper numbers of fish to stock. Because most ponds are roughly triangular in shape, a rough estimate of the size can be calculated by stepping off – about 2 1/2 feet per step – the length of one shoreline, then stepping off the width of the pond at the dam.



Multiply the length and width, divide by the number of square feet in an acre – 43,560 – and divide by two. This will give a close approximation of the pond size in acres.

$$\text{Area} = (\text{length} \times \text{width} \div 43,560) \div 2$$



Another option: Obtain a “Pond Area Estimator” leaflet from a Conservation Department office.

When to stock

Because the chance of a new pond becoming contaminated with undesirable species increases as the pond ages, stocking should occur as soon as possible. If there is any doubt about a pond holding water, stock it for less than the planned original size. Many ponds have failed to produce good fishing because they were stocked at too high a rate. This often happens when a pond has a leak or the owner miscalculates the size when ordering fish. The pond fish population will develop more favorably if it is a few fish short of the recommended stocking rate rather than if stocked with too many fish.

Minimum water depth

Water depth in a new pond is an important factor to consider when stocking. The water in a pond that is still filling should be a minimum of 5 feet deep to ensure winter survival of fish stocked in the fall.

The small fish that the Conservation Department provides for stocking will survive temporarily in shallow water. But as the fish become larger, a depth of at least 8 feet is necessary, especially in north Missouri.

Hauling and handling

Getting the fish to the pond in good physical condition is essential to produce a healthy population. One way to keep them in good shape is to get them to the pond as quickly as possible. A delay in transport can cause oxygen levels in the water to drop and water temperature to rise, which cause fish to become stressed.

Care in handling also is important. Any wound may become infected by bacteria or fungi. Although the fish may go into the pond alive and wiggling, they may later die from these infections. Stressed and wounded fish rarely live long enough to become lunkers. To minimize problems, use water from your pond to fill the containers you use to transport your fish.

If there is a temperature difference of 5 degrees or more between the pond and the water in your hauling container, submerge the hauling container in the pond and slowly exchange water until the temperature of the water in the container is the same as that in the pond. Reducing the temperature difference between the transport water and the pond water will help prevent the fish from dying due to shock.

Sources of fish

The Conservation Department recognizes that the development of new ponds, stocked and managed according to its recommendations, is an effective way to provide more fishing opportunities. To encourage pond fishing and decrease fishing pressure on public waters, the Department provides fingerling largemouth bass, bluegill and channel catfish for stocking new private lakes and ponds. It also will stock fish in recently renovated ponds where the fish have been chemically killed out in accordance with the Wildlife Code of Missouri.



Note: *Bluegill and channel catfish are available for stocking in September and largemouth bass the following June. See Appendix B on page 60 for requirements and procedures.*

Pond owners who receive these fish agree to allow a reasonable amount of fishing, but access to the pond remains in their control. Commercial sources of fish are available throughout Missouri. Check your local Conservation Department office for recommendations on the appropriate species, numbers and sizes to stock, and to obtain a list of commercial fish dealers.

Obtaining fish from commercial dealers can mean quicker fishing from your pond because you may stock larger sizes and fish are available most of the year. All fish may be stocked at one time. It also means that anyone you wish may fish your pond without a fishing permit, as long as you maintain a receipt for the fish purchased and provide successful anglers with a receipt for fish that are taken from the property.

Stocking a pond with fish taken from creeks, lakes or other ponds is not recommended. The chances of getting undesirable species are high, and the probability of producing high quality fishing is low because it is difficult to obtain a balance of fish species and sizes that will sustain good fishing.

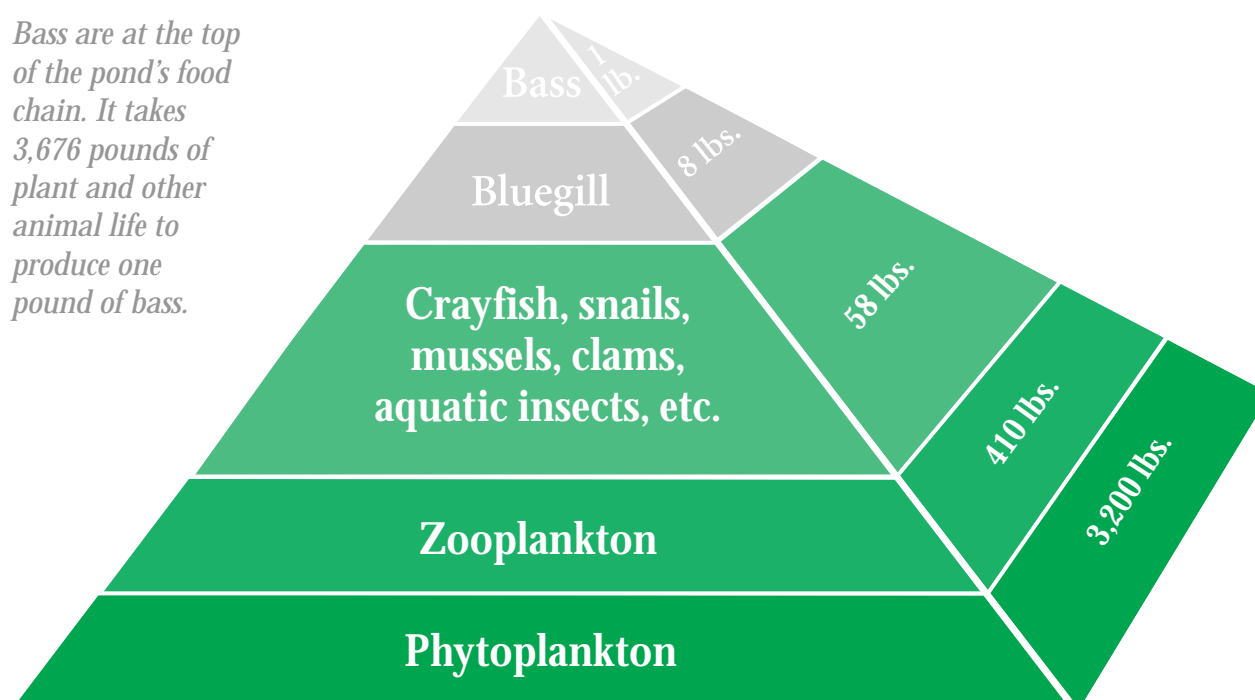
Contrary to common belief, fish or fish eggs are not carried into ponds by birds. Fish of unknown sources often get into ponds by migrating from water sources upstream or even downstream during runoffs. Some anglers think they can improve the fish population by dumping minnow buckets or releasing their catches from other areas in your pond. This often introduces unwelcome species and should be discouraged.

Producing fish in your pond

All crop production is based upon energy passing from the sun to the final product, whether it is lettuce, soybeans, beefsteak or largemouth bass. Plants are the first or primary converters of the sun's energy into a form that can be transferred to plant-eating animals. The progression of the sun's energy through plants and animals is called a food chain.

A simple and widely known food chain is one that involves beefsteak and people. Soil containing essential minerals, nutrients and moisture in the presence of sunshine produces grass. Cattle feed on and use the energy and organic matter stored in the grass. People eat the processed beef and use the energy and organic materials that the cattle converted and stored. The pathway of energy is from the sun through grass, livestock and finally to people.

Bass are at the top of the pond's food chain. It takes 3,676 pounds of plant and other animal life to produce one pound of bass.



The food chain in a pond is similar but much more complex because of the many different kinds of organisms found at each level. In Missouri ponds, the water contains dissolved nutrients and minerals from the soil that are essential for plant growth.

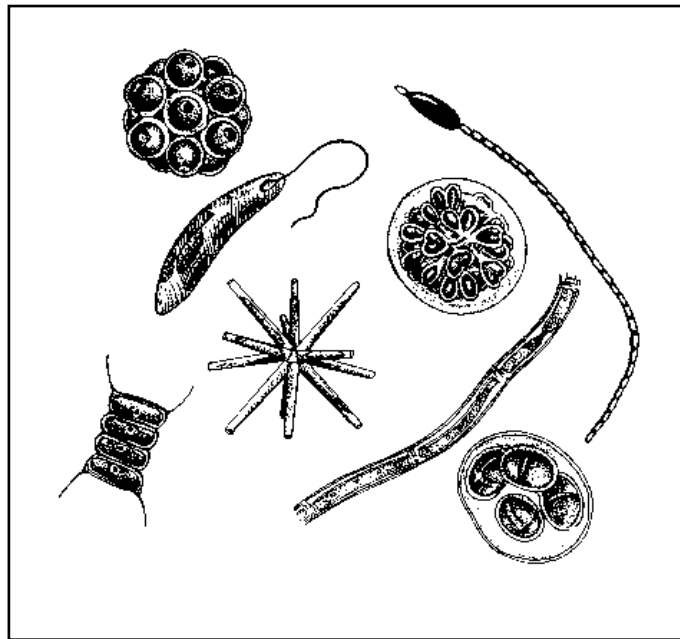
The pond's most important producers are

microscopic plants called phytoplankton. These plants may give ponds and lakes a slight green color. Rooted aquatic plants and filamentous algae, or pond moss, also are a part of the first link, but they are used less efficiently by animals.

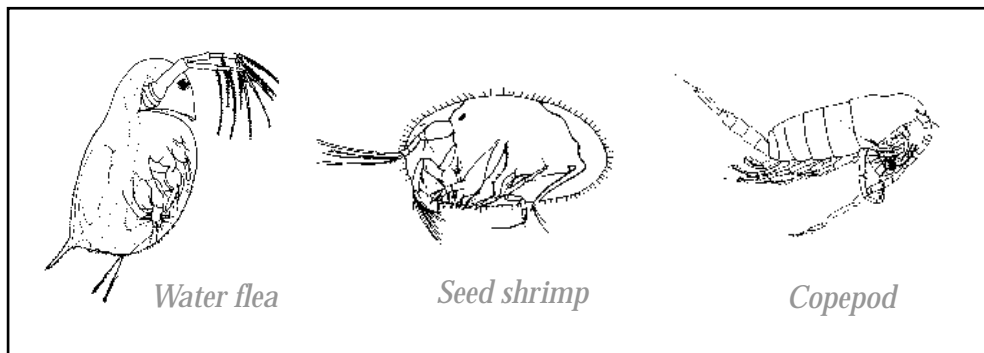
The first animals in the pond's food chain are the zooplankton. These very small organisms eat the phytoplankton and use the plant's energy to grow and reproduce. Aquatic insects are another important link in the aquatic food chain. Dragonflies, damsel flies, mayflies and many other insects frequently seen near ponds and lakes are adult stages of insects that spend their larval life underwater. These aquatic insect larvae feed on both the zooplankton and phytoplankton and are, in turn, eaten by fish.

Small fish eat plankton – primarily zooplankton – and larval aquatic insects. As they get larger, bluegill continue to eat insects and some plankton. Bass, however, switch to eating mostly fish at a young age. Few big bass can be produced without other fish as a food source.

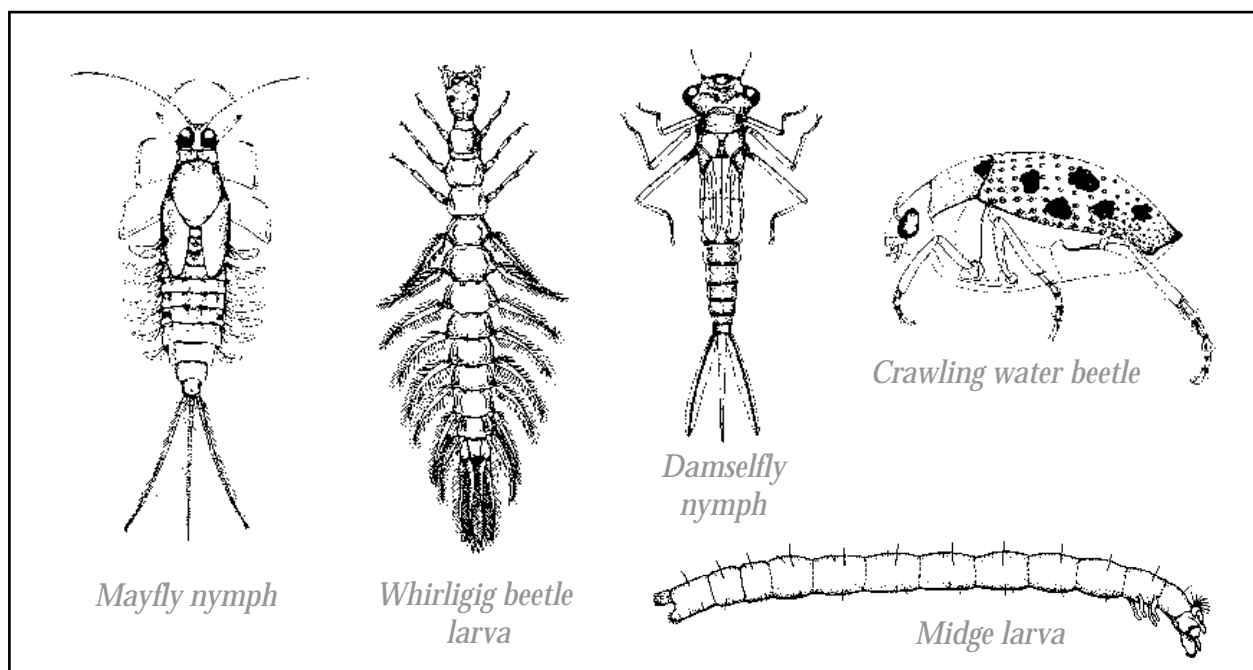
Small fish concentrate the energy taken from the food they eat, which provides a high energy packet for larger fish. Because bluegill are lower on the food chain than largemouth bass, a pond will support five to 10 times as many pounds of bluegill as it will largemouth bass.



Microscopic phytoplankton provide food for fish and give ponds and lakes a slight green color.



Minute zooplankton, such as these, eat phytoplankton and are, in turn, eaten by aquatic insects.



Aquatic insects and their larvae, such as the ones above, provide food for smaller fish that are, in turn, eaten by bass.

In a good fishing pond, the water contains all the necessary ingredients for fish production. Sunlight enters the water causing plants to grow and produce food. This is the basis for fish production. Remove or alter any link in the chain and the final product – good fishing – will suffer.

Carrying capacity

About three years after stocking, the pond will achieve its weight limit, or carrying capacity, of fishes. In Missouri, carrying capacities range from about 20 pounds per acre of water to as much as 600 pounds per acre depending on the dominant fish species, the size of the fish and the fertility of the soil in the drainage area.

When the carrying capacity is reached, fish growth will slow down until some fish die or are removed. Ten-year-old ponds in Missouri average about 250 pounds of fish per acre of water. This usually includes about 190 pounds of bluegill, 35 pounds of largemouth bass and the remainder will be catfish and other species. If you remove 25 pounds of fish, 25 pounds will grow back. This 25 pounds of fish may grow back as 100 4-ounce fish, or perhaps five fish of 5 pounds each, or any combination of sizes and numbers equaling 25 pounds.



Important management note: *The size and number of each species harvested will affect the size and number of each species that grow back.*

Supplemental feeding is not necessary in well-managed ponds. In fact, the rate of pond aging may increase because of the accumulation of nutrients from uneaten food and the increased waste products of the fish. Commercial feed can be used, however, to increase the pounds of fish

harvested or to raise larger fish. Sunfish and channel catfish will be the most active feeders. Bass will not normally eat commercial feed, but may benefit from increased production of small bluegill.

Once feeding is started, it should be continued. The increased weight of fish may exceed the pond's natural carrying capacity, and the fish will become thin if feeding is stopped. Do not feed fish when water temperature is below 45 degrees Fahrenheit, and feed only once a week when the temperature is between 45 and 70 degrees.

If you wish to feed your fish, use only floating catfish food and feed daily only what is totally consumed in 10 minutes. If your fish fail to come up to feed, cut back to one handful or less of feed a day until they are actively feeding again. If your fish are not feeding, it may be due to some stress factor, such as low oxygen levels, too cool water temperatures, disease or a parasite problem.



Warning: *Watch your fish's feeding habits. If supplemental food is continued at normal rates when fish have stopped vigorous feeding, a fish kill could result.*

Feeding increases the amount of organic matter in the pond, and the decay of this material uses oxygen from the water. As fish are fed they become larger, perhaps exceeding the pond's carrying capacity. If they do, the pond may not be able to produce enough oxygen to support the larger fish or to supply the oxygen removed by the decaying matter. This problem intensifies on hot, cloudy summer days. If you use commercial food, you must harvest fish before they become so large that their accumulated oxygen demand is greater than the oxygen available.

Low oxygen conditions also may result from feeding fish. The nutrients released by decay of waste products or from decaying uneaten food may stimulate a bloom of algae, which can cause oxygen levels to drop low enough to kill fish at night or on overcast days. When this occurs, fish will be seen early in the morning "gasping" at the surface for oxygen.

Oxygen depletion also may develop if uneaten fish food decays in the water. Fish kills due to oxygen depletion also may occur in any pond if algae populations are high and cloudy weather is prevalent.



For more information: *Order the Conservation Department's aquaguide "Fish Kills in Ponds and Lakes."*

Managing for good fishing

Good fishing cannot be guaranteed, but the chances of having a good fishing pond will be improved with careful management. Once the pond is stocked with the proper number of fish in the proper ratio, management becomes a matter of keeping the water clear, the vegetation in balance and making the proper harvest decisions.

Trying to raise a fish crop in muddy water is a lot like trying to grow a garden under your front porch. Without sunlight, microscopic plant growth

ceases, and all water animals dependent upon this food source fail to grow and reproduce in adequate numbers. This results in slow growing, small fish.

Bass grow up to five times faster in clear water. Growth in muddy water is slower because natural fish food production is greatly reduced and the fish cannot see well enough to find the food that is available. Extremely clear water, however, usually is an indicator of an infertile pond that may be incapable of producing enough food to support desirable numbers of fish.



Note: *A pond may be considered about right for good fish production if you can see your fingers when you place your arm 18 inches vertically in the water while in direct sunlight.*

Cover in the form of vegetation also is important to your fish, so do not try to eliminate it all. A rule of thumb is that aquatic vegetation is too thick when more than 20 percent of the surface area of the pond is covered.

It is especially important to control excessive amounts of aquatic plants. Too much plant growth may interfere with fishing and may provide too much cover for small fish. This keeps the bass from finding enough to eat, and the number of small bluegill won't be controlled. The resulting swarms of small, slow-growing bluegill will raid bass nests and limit the number of bass produced. Poor fishing is the result.

Harvesting fish

You may begin fishing the second summer following stocking, but special care is required the first three years. By fishing, you have the opportunity to check on the fish's growth. All fish, however, must be handled carefully and returned to the pond. It is important to have good survival of all fish until they mature and spawn.

After one growing season, bass should average 8 to 9 inches, bluegill 4 to 6 inches, and channel catfish 11 to 12 inches in length. If your fish are larger, growth has been excellent. If your fish are smaller, something is restricting growth and it will take longer for them to reach a catchable size. Every fish is important so return them to the water quickly.



Note: *Largemouth bass are the key to good pond fish management, and harvest of this species should be closely regulated and monitored. Harvest of too many will allow bluegill to become numerous and slow-growing.*

Bass in their predatory role consume large numbers of bluegill, keeping their numbers in check. The bluegill that escape being eaten grow rapidly and provide angling pleasure and delicious eating. Bass grow to a relatively large size and provide an angling challenge for pond owners and their friends. Regulating the harvest of bass is essential to maintaining proper balance, an extremely important concept in managing your pond's fish populations. A balanced pond is one where there are enough bass to keep the bluegill numbers in check, but not so many that they eliminate all the

young bluegill. Bass should be able to find sufficient food to grow well, and the surviving bluegill should find enough food to grow well and produce abundant offspring to support the bass population and angler harvest.

The total number of fish in a mature pond in Missouri can range up to 1,000 or more per acre. Most fish will be too small to interest anglers. With good pond management, a surplus of larger fish will be available for harvest. If more than this surplus is harvested, your pond will be out of balance and you may have long-term problems with your fish population.

Population problems of bass and bluegill are easy to identify with a few hours of fishing. Keep good records of the sizes of fish caught, and those removed. This is essential to arriving at the proper harvest rates for all species in your pond.



Tip: *A few hours fishing can reveal much about your pond's balance. For best results, catch 10 or more bass and accurately measure and record their lengths. If some bluegill are caught and measured, the conclusions drawn will be even more reliable*

At one extreme of an unbalanced pond, you will catch either few or no bass and many small bluegill that are less than 5 inches long. The other unbalanced extreme will have many small bass and few to moderate numbers of 6-inch or larger bluegill. If there is any indication that the population is moving toward either of these extremes, management changes may be necessary. Unfortunately, the exact condition of your fish population may fluctuate at any particular time, and it may be difficult to determine its exact status using fishing techniques.

Harvest of your top predator, the largemouth bass, should be conservative. The system will work well if it is managed to maintain the correct number of bass, which in turn, maintain the correct number of bluegill. Angler harvest of some bass is generally required to keep their numbers in balance with their food supply.



For more information: *Send for the Conservation Department's aquaguide "Good Record Keeping Means Better Fishing" to help you manage your fish populations.*

It is generally not possible to have large numbers of large bass and large numbers of large bluegill in your pond at the same time. You must decide what you want from your fish population. Carefully read about the different possibilities in the section on improving and maintaining your fish population on page 41, and weigh the positive and negative factors in each scenario. The recommendations below must be evaluated in light of your management goals.

Largemouth bass

Largemouth bass may be harvested after they have spawned at least once. At that time, the 100 bass per acre originally stocked will have dwindled to 70-80 fish because of natural mortality. Their length will be from 10 to 14

inches. These original bass must maintain predation pressure on the bluegill, which probably will have spawned twice before the first bass offspring are 8-10 inches in length. This translates to a harvest of no more than about 20 bass per acre a year starting after their first spawn. This is an average figure for ponds across the state. The correct figure for your pond may be higher or lower and depends on what you want out of your pond, the fertility of the drainage area, the clarity of the water and many other factors.



Note: *You may want to limit bass harvest to those larger than 15 inches for the first five years after stocking. As your fish population matures, watch the bluegill population carefully.*

If you are catching or seeing bluegill from 1 inch to 8 inches or more and a variety of sizes of bass, things are fine. If you see few bluegill less than 4 inches and many small bass, there may be too many bass in the population. Depending on what management option you have chosen, some may need to be removed.

Bluegill

Adult bluegill may be harvested up to 75 to 100 per acre a year. Bass and bluegill harvest must be balanced so that you always see bluegill less than 2 inches long in the weeds and shallow areas of the pond. Bass of all sizes should be present and in good condition.

Channel catfish

Channel catfish can be harvested as soon as they reach a desirable size. They must be restocked periodically to maintain a fishable population. Stock fish a minimum of 8 inches in length to replace the numbers harvested, plus 10 percent to compensate for natural mortality.

Why ponds fail to provide good fishing

- ✓ Other fish were present before the pond was stocked with hatchery fish or other fish entered the pond after it was stocked.
- ✓ Largemouth bass were over- or underharvested.
- ✓ Stocked fish died due to handling stress, pesticides or natural causes.
- ✓ The pond is too shallow to support fish.
- ✓ Too many, too few or the wrong species of fish were stocked originally.
- ✓ The water is too muddy for sight-feeding fish to find food.
- ✓ Aquatic vegetation is too abundant.
- ✓ Small fish do not have enough cover in which to hide from larger fish.

Managing an old pond

Suppose you have recently purchased some land with a pond, or you have a pond that has been neglected for a while and you would like to use it for fishing. You can improve its condition so that it will produce a quality fishing experience.

Evaluating your pond

To evaluate the fishing possibilities in your pond, answer the following questions. If you answer “no” to all of them, consider yourself lucky: you have a promising fishing pond. More likely, you will have a few “yes” answers. Most of these problems can be corrected if you follow the recommendations.

Is the pond less than 8 feet at the deepest part? Measure it. Don't guess.

Ponds less than 8 feet deep are a fish kill waiting to happen. It might be this year or in five years, but eventually the lack of water will cause the dissolved oxygen level to drop too low to support fish life. An alternative is to physically renovate the pond by draining it, drying it out and removing enough of the accumulated sediment or original soil to create deeper water.



Caution: *Removal of the original soil may allow the deepened pond to leak. All black muck should be removed and placed where it cannot be washed back into the pond, but you should not excavate below the original ground level.*

This muck is a storage area for nutrients and seeds. Any muck left in the pond basin will allow instant growth of excessive vegetation in the renovated pond.

Another alternative is to maintain a fishless pond as habitat for insects, toads, frogs, reptiles, salamanders and waterfowl. Some of these animals will not thrive in the presence of fish.



For more information: *Send for the Conservation Department's booklet "A Guide to Amphibian and Reptile Conservation" to attract other aquatic animals to your pond.*

You may wish to install an aerator to maintain adequate oxygen to support fish. Contact the nearest Conservation Department office for information.

Is the pond less than 1/4 acre in surface size?

Small ponds can sustain fishing, but the fish populations must be managed carefully. Catch-and-release fishing is often the answer.

Are the banks, dam or spillway eroding?

Any bare areas around the pond should be filled, shaped, fertilized, seeded and mulched. This will limit the accumulation of soil on the bottom of the pond and will eliminate this source of silt, which can cause muddy water. Be sure to repair any erosion on the dam as soon as possible because further damage or dam failure could occur from runoff during a heavy rain.

Is there evidence of burrowing animal damage on the dam?

This damage could lead to dam failure. Burrows and dens on the dam should be caved-in, filled, tamped solid, seeded and mulched immediately. The offending animals should be removed or destroyed.

Are trees growing on the dam?

Keep the dam mowed front, top and back to control the growth of woody vegetation. Tree roots will penetrate the dam in their quest for nutrients and water. When the tree dies, the roots decay, leaving an open channel for water to penetrate the dam.

The removal of trees and shrubs larger than 4 to 6 inches in diameter will leave roots in the dam, which will require attention as they decay. It is generally recommended to leave growth of this size and larger, unless the pond owner is willing to rebuild the dam to eliminate the roots.

Do any of the following drain into the pond?

- ✓ septic field or sewage line
- ✓ heavily fertilized cropland or lawns
- ✓ barnyard
- ✓ feedlot
- ✓ heavily grazed pasture
- ✓ any other source of organic waste

Any of the above might be a source of excess nutrients to your pond. If you eliminate any or all of these sources, you will increase your enjoyment of the pond and extend its lifespan.

Do livestock have access to the pond?

Livestock can have a negative impact on ponds. The animals decrease the volume of deep water with each step because they move soil away from the bank and shallow areas toward deeper areas.

This creates a wide shallow shelf where vegetation grows readily. They also can deposit large quantities of waste products into the water while cooling off on hot summer days. This contributes to nutrient build-up in the pond

and will eventually lead to increased levels of vegetation.

Decaying manure also can lead to low oxygen levels that may cause a fish kill. Livestock can make the water muddy and unproductive and may disrupt fish spawning activities. Lastly, any chemicals used to control livestock pests may be washed off the animals and contaminate your pond or cause a fish kill.

Are there any sources of chemical pollution in the watershed?

You may have a problem with pollution if you see an accumulation of pesticide containers or an unexplained bare spot in the area that drains into the pond. You must eliminate the source of pollution and clean up the watershed, the water and the silt on the bottom of the pond before any efforts are made to manage or harvest the fish population. The existing fish should be removed, the pond restocked and a fresh start made after the pollution sources are removed and clean-up is completed.

In summer, do water plants or algae cover more than 1/4 of the pond surface?

Control of excessive aquatic plants is discussed in the section on aquatic plant management on page 46.

In summer is the pond completely barren of aquatic plants?

Three different conditions can cause this problem. The most common is muddy water. Sunlight must be able to penetrate to the bottom at least in the shallower areas before plants can sprout and grow.

Too many grass carp also may cause a pond to be devoid of vegetation. If this is the situation in your pond, order the Conservation Department's aquaguide on grass carp fishing techniques to learn how you can remove some of the fish and allow plant growth to recover.

Overuse of plant control chemicals may destroy a pond's aquatic vegetation.

Can you see a white object when it is extended 18 inches deep in the pond while in direct sunlight? Is this due to muddy water? Is the water green?

Ponds will produce more fish if a white object can be seen at least 18 inches deep, but not more than 30 inches deep, in direct sunlight during the growing season. If green water color is limiting sunlight penetration to less than this range, you need to limit the amount of nutrients in the pond.

If this is the case, wide fluctuations in the quantity of dissolved oxygen in the water will occur between day and night. These fluctuations can be stressful to fish. This condition is common in aging ponds that have accumulated quantities of nutrients. Alternatively, it may be due to excess nutrients added to a younger pond from a pollution source.

Possible sources of excessive nutrients include: excessive fertilizers in the watershed, septic tank overflow, cattle barns, poultry barns and feed lots. If your pond is much clearer than the suggested range, you may need to add some nutrients to increase the pond's fertility. Contact the nearest Conservation Department office for recommendations.

If your pond is muddy, raising channel catfish may be an option because they do better under these conditions than sight feeders like bass and bluegill. Fathead minnows can be stocked to provide some food for the catfish and give anglers a supply of bait.

Supplemental feeding may be necessary for adequate channel catfish growth. Channel catfish can reproduce successfully in muddy water ponds. See page 36 for harvest recommendations.

Does your pond lack hard cover, such as brush piles, fallen or flooded timber or rock piles?

Improve your angling success by giving your fish better habitat. Fish attractors can be made from tree branches, cedar trees and old Christmas trees. Discarded lumber or old boards can be used to create a fish condominium. These structures will provide cover for fish and living places for the aquatic insects they eat.

One way to get these structures in the right place is to build them on ice thick enough to safely walk on. Secure branches and trees to a heavy weight with a cable or nylon rope. They will sink into place when the ice thaws. Hardwoods will last longer than softwoods.

You may want to put in several fish attractors at varying places and depths in your pond, but none should be deeper than 12 feet. Additional habitat can be made by cutting two-thirds of the way through a tree on the shore and letting it fall into the water, leaving it attached to the stump.



For more information: Send for the Conservation Department's aquaguide "Fishing in a Barrel" to find out how to place fish attractors in your pond.

Evaluating your fish population

What is the condition of the fish population in your pond? Is it in balance? Here's some methods that can help you find an answer to your particular situation.

Go fishing

An enjoyable way to find out about your pond's fish population is to spend some time fishing. By catching and examining fish from the pond, you can

determine the species of fish, their abundance, average size and general health.

A variety of baits and techniques should be used. Try to fish the pond with both artificial lures and natural baits. Fish at various times of the day. Early morning and late evening might be best for bass, whereas bluegill fishing can be productive any time of the day. Smaller lures, hooks, baits and bobbers will enhance your fishing success.



Note: *The more fish you catch, the better the evaluation of your fish population will be.*

Keeping records

It is essential to keep records of the date, hours spent fishing by each angler, number of anglers, the types of fish species caught, and the lengths of fish kept and released. All of this information is important in determining the status of the fish populations in your pond. It is best if at least 10 bass and 10 bluegill are caught, or at least five fishing trips are taken with at least 10 hours of total fishing effort.



Tip: *The more time spent and the more fish recorded, the better your data will be. Be sure to measure the length of the fish accurately. Don't guess. Accurate records mean better management decisions and better long-term results.*

For more information: *To get the most enjoyment out of your pond, send for the Conservation Department's aquaguide, "Good Record Keeping Means Better Fishing."*

Analyzing your records

You can interpret your records yourself, using the information given in the following paragraphs, or you can send it to the nearest Conservation Department office for analysis.

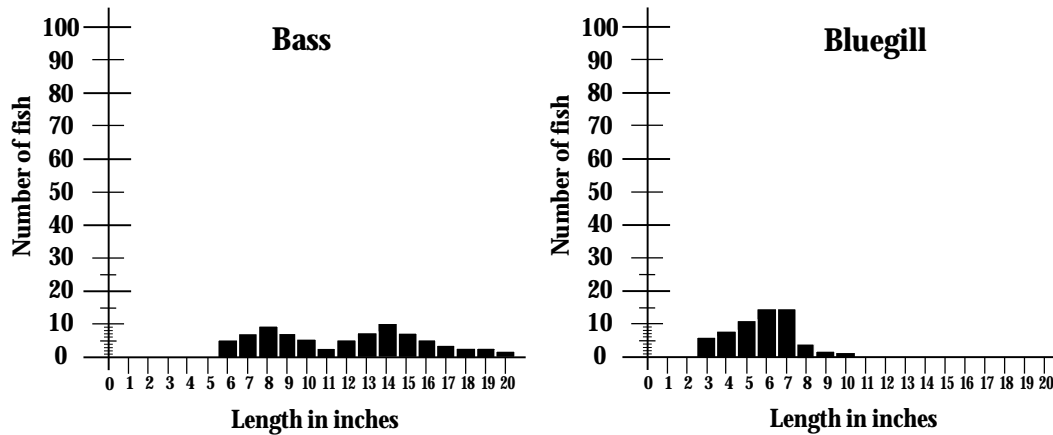


For best results: *Always record your fishing success and the fish caught. Compare their size to past entries to see if the fish population is changing.*

Improving and maintaining your fish population

Your fishing records will probably reveal one of the following situations. The management recommendations for each situation should help you maintain or improve your bass and bluegill populations to keep them in line with your goals for the pond.

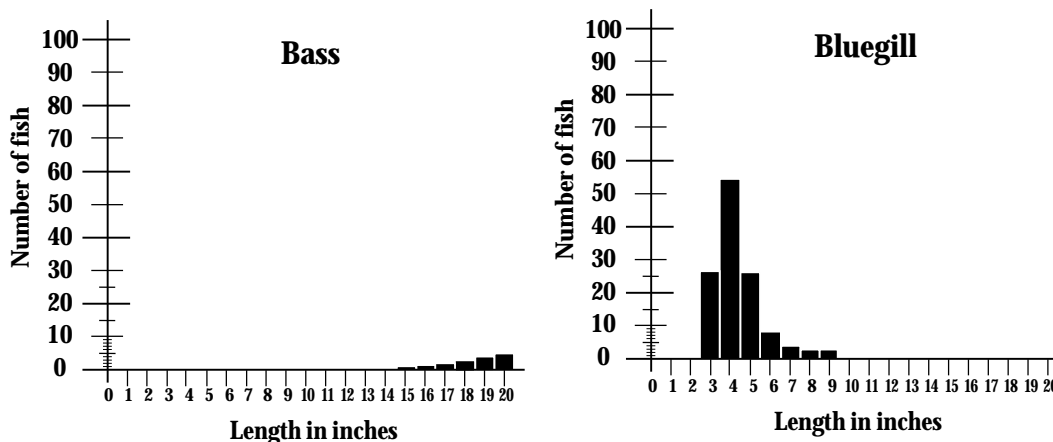
Balanced population



Your catch consisted of bass, bluegill and perhaps channel catfish, but few if any other species. More than half of the bluegills were 6 inches or larger. The bass, which were accurately measured, were 12 to 16 inches in length, although some smaller ones and some larger also were caught.

Recommendations: This is a desirable, balanced fish population and will produce quality fishing. Keep following past management and harvest practices.

Unbalanced population with many small bluegill and few large bass

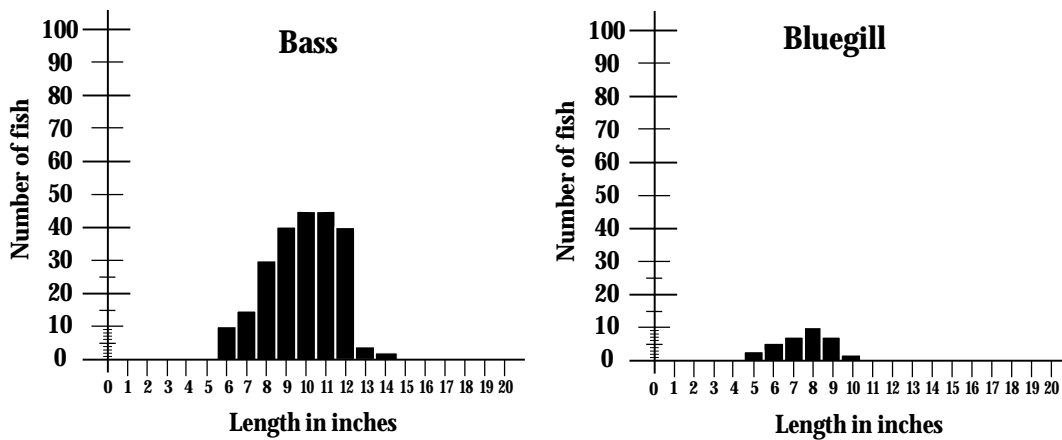


As in the first situation, your catch consisted almost entirely of bass, bluegill and channel catfish. However, most of the bluegill were 3 to 5 inches long, and few bass were caught. Most of the bass were larger than 15 inches. The pond may have more than 20 percent of the surface or bottom covered with rooted plants.

Recommendations: This is an unbalanced population, with overcrowding by bluegill. You should:

- ✓ stop bass harvest until the situation is corrected.
- ✓ consider stocking 10- to 12-inch bass at a rate of 10 to 40 per acre.
- ✓ consider protecting bass by restricting their harvest. Future bass fishing and bluegill control depend upon releasing bass.
- ✓ harvest bluegill as rapidly as possible to reduce numbers.
- ✓ evaluate the amount of vegetation. If there is too much, see pages 46-50 for control methods.
- ✓ renovate the pond to remove unwanted fish only as a last resort.

Unbalanced population of crowded bass and big bluegill



The catch was nearly all bass, bluegill and channel catfish. The bluegill were quite large and in good condition, but almost all bass are between 9 to 11 inches in length, and were obviously not in good condition. This situation can produce excellent bluegill fishing; but if allowed to continue, it may eventually result in few or no bluegill in the pond.

Recommendations: This is an unbalanced population, but one that results in a high quality fishery for large bluegill. For more details, see the Conservation Department's aquaguides "Stockpiled Bass – A Common Pondowner Complaint" and "Managing for Trophy Bluegill."

If you wish to shift to a population structure of larger bass, you need to harvest 20 to 30 bass per acre a year if your pond is in southern Missouri and 30 to 35 per acre a year if your pond is in northern Missouri. In some situations, you may need to remove more. Check with your nearest Conservation Department office for help.

Using your records, determine the size of bass at the upper end of the group of stockpiled bass. If most of the bass are between 8 and 11 inches, for example, you should release all bass that are over 10 1/2 inches and harvest the ones that are 8 to 10 1/2 inches.

Good record keeping is essential as you remove bass from the population. Keeping track of the rate of bass caught per person per hour over time as fish are removed should indicate a downward trend in the number of bass caught per hour. When this catch rate falls to approximately one-half the value calculated at the start of the removal project, you need to consider reducing the rate of bass harvested. Continue to fish and record lengths of bass to detect any population changes. An increase in the catch rate should prompt you to consider harvesting more bass from the most numerous group of fish.

A lack of cover also may cause an unbalanced pond with crowded bass and big bluegill. Allowing more vegetation to grow by removing grass carp or stopping chemical vegetation treatments and by adding brush piles will provide more cover for small bluegill and promote better growth of small bass.



For more information: *The following aquaguides from the Conservation Department will help you balance your fish population: “Fishing in a Barrel,” “Harvesting Grass Carp” and “Turn Your Pond into an Aquatic Briar Patch.”*

Balanced population with additional species

Your catch included some large bullheads, 3- to 6-inch sunfish – other than bluegill, or medium-sized crappie 8 to 10 inches. You also caught bass and bluegill of several sizes that appeared to be in good shape. Most of the bluegill were 6 inches or longer.

Recommendations: As long as the bass and bluegill populations remain healthy, no extraordinary measures are necessary. However, this situation bears close watching and careful management. Remove, within statewide limits, all bullheads, crappie and sunfish – other than bluegill – as caught. Bluegill may be harvested as desired.

Unbalanced population with additional species

You catch large numbers of fish other than bass and bluegill, such as bullheads, green sunfish, crappie, carp and others. Most of these fish are less than acceptable size. Few to no bass are caught.

Recommendations: This pond can provide a lot of angling pleasure, but it won't produce a quality harvest. Renovation by chemically killing all fish may be necessary when large numbers of other species or bluegill are present and few bass are found.

Pond renovation

Renovation may be done any time of the year, but the best time is in August or September. This should be done from two to four weeks before the pond is to be restocked to allow time for the chemical to become nontoxic. The water should be tested by leaving a few minnows in a bait bucket in the pond overnight to determine if the chemical has disappeared before new fish are stocked.

The pond can then be given a fresh start with a new stocking of bass, bluegill and channel catfish. Renovation should be used as a last resort because it will be several years before the pond can be fished again.

The most commonly used chemical is rotenone, a naturally occurring organic chemical extracted from the roots of certain tropical plants. Rotenone kills fish by making it impossible for them to absorb dissolved oxygen from the water. The chemical kills only animals with gills. Animals such as frogs, turtles, muskrats and ducks are not affected.



Note: *You will need a permit, available free from the Conservation Department, before your pond or lake can be renovated. The Department also can help locate a source of rotenone and a licensed commercial applicator.*

Nonfishing ponds

Perhaps, after evaluating your old pond, you will decide that it is not suitable for fish production. It may be too small, too shallow, leak too much, or is too enriched from nutrient sources in the watershed that cannot be diverted.

Even ponds such as these can be managed in ways that bring their owners enjoyment and, in some cases, profit. Some of these uses are:

- ✓ raising bait fish or crayfish
- ✓ providing habitat for frogs, turtles, snakes and salamanders
- ✓ creating a marsh or waterfowl area.



Tip: *More information on each of these management options is available from any Conservation Department office.*

Common pond problems and recommendations

Small pond management

Bass, bluegill and channel catfish can be successfully managed in small ponds; but the harvest may be too limited, and sustained good fishing may be hard to maintain.

For example, in ponds less than $\frac{1}{4}$ acre, some harvest must be done to keep the fish species, sizes and numbers in balance, but the removal of even one or two bass too many can destroy the balance.

A $\frac{1}{4}$ -acre pond will receive an initial stocking of 25 bass fingerlings, assuming the maximum rate of 100 bass per acre. Seventy percent of these fish can be expected to survive under good conditions until they are large enough to harvest. That leaves about 18 bass.

Anyone who has experienced the first day of fishing in a new pond knows that most of these fish could be caught in one afternoon. Unless they were put back to be caught again, the bass population would be nearly wiped out.



Important information: *To maintain a good bass population in a small fishing pond, no more than three to five bass should be removed each year.*

Adult bluegill may be harvested up to about 25 per year. About 125 should have been stocked originally, and they will have declined to about 75 before being large enough to be of interest to anglers. Those 75 must not be harvested until they have spawned for the first time.

Channel catfish should be restocked as fish are harvested. Stock a minimum of 8-inch fish at about 20 per acre of water every other year after the third year of channel catfish harvest, or at a rate to replace those caught plus 10 percent. Keep good records of those stocked and harvested so that you can maintain a population of less than 60 per acre.

Aquatic plant management

Plants are essential to the fish living in your pond, and they are as natural to the aquatic environment as they are to the terrestrial landscape. Microscopic plants are the prime producers of the food and oxygen needed by most aquatic animals.

The larger plants produce food and oxygen for aquatic animals, places for microscopic plants and animals to attach themselves, and shade and hiding spaces for fish and other pond dwellers.



For more information: See the Conservation Department's aquaguide "*Turn Your Pond into an Aquatic Briar Patch*" to improve cover and food for fish in your pond.

Like fish, the plant population needs to be kept in balance. Too many large plants can restrict boating, swimming and fishing and can detract from the pond's beauty. They also can provide too many hiding places for small fish. When the bass can't find the smaller fish to eat, an unbalanced fish population is the result.

A very dense bloom of microscopic plants, like phytoplankton, imparts a soupy green quality to the water that most people find unappealing. This bloom of vegetation may cause a fish kill if large quantities of the plants die and decay over a short time because the decay process depletes the oxygen supply in the water.

This happens most often during the summer when the water temperature is at its highest and the amount of oxygen in the water is low. A rapid change in water temperature or several cloudy days in a row can also cause plankton to die off suddenly.



Caution: See the Conservation Department's aquaguide "*Fish Kills in Ponds and Lakes*" for more details about how you can keep your fish population healthy.

Types of plants

Aquatic vegetation may be grouped into four broad categories:

- ✓ Algae include many species of microscopic plants and some species that look like a submersed rooted plant.
- ✓ Floating plants, such as duckweed and watermeal, are not attached to the bottom and float freely on the surface.
- ✓ Submersed plants are rooted to the bottom and grow beneath the surface, however, a few have leaves that float on the surface. Some common ones are the pondweeds or *Potamogeton*, coontail, milfoil, elodea, American lotus and watershield.
- ✓ Emergent plants grow above the surface and along pond edges. Common examples include cattail, sedges, rushes and arrowhead.

Controlling aquatic vegetation

The method for controlling vegetation in ponds depends upon the species and circumstances. To identify problem aquatic plants and to find out how to treat them, consult the Conservation Department's booklet "Nuisance Aquatic Plants in Missouri Ponds and Lakes" and the aquaguide series on aquatic weed control.

Mechanical and physical control

Excessive aquatic plant problems in your pond can be reduced if you deepen the pond edges so that most of the area is at least 3 feet deep. Deepened edges, however, will not eliminate all aquatic plants.

Nuisance aquatic vegetation in small quantities may be controlled by pulling, digging, cutting or raking. Cattails, willows, bullrush, water willow, water shield, water lilies, lotus and water primrose may be kept under control by removing new growth. Aquatic plants grow fast, so you should weed often. To keep the plants under control, you may have to weed all summer. Underwater weed cutters are available, but are expensive and not practical for ponds.

Covering the pond bottom with black plastic will control many species, but the unsightly appearance of the plastic may be objectionable in some locations. Sheets of black polyethylene 6 to 8 millimeters thick and 40 to 100 feet long can be placed in the water and anchored in place by fastening the corners to cement blocks or covering it with gravel. Puncture the plastic with numerous small holes to permit the escape of gas bubbles, or the plastic will float to the surface. Exclusion of sunlight kills most plants in a few days. This method doesn't always work well in areas where muskrats are numerous because the animals often damage the plastic.

Using aquatic dyes to shade sunlight from filamentous algae can be effective. However, the use of dyes may decrease fish production by eliminating desirable algae populations necessary for production of food and oxygen.



Beware: *Muddy water shades the bottom and eliminates most submersed aquatic plants, but it should not be created to prevent plant growth. Shading severe enough to retard plant growth will reduce fish growth in the pond.*

Biological control

Few practical methods of biological control are available or recommended for Missouri ponds. Certain fishes, crayfish, snails, insects and plant diseases have been tried, but results have been disappointing. Sometimes the control organism is worse than the original problem.

Grass carp do not reproduce in ponds or lakes and have proven valuable in many situations. These large members of the minnow family feed almost exclusively on aquatic plants, eating two to three times their weight each day. Grass carp have definite preferences for certain types of vegetation, eliminating all of those types before impacting those less palatable. Algae is not eaten until all other vegetation is gone.



For more information: *Send for the Conservation Department's aquaguides on harvesting grass carp and on using these fish to control weeds in ponds and lakes.*

Another method of biological control is fertilization. Periodic applications of fertilizer, such as soluble ammonium phosphate, can produce tremendous quantities of phytoplankton. The bloom can become so thick that it shades the bottom much the same as black plastic or clay turbidity.

Once you start fertilizing, you usually have to keep it up on a regular basis during the growing season. If fertilization is stopped, nutrients tied up in microscopic algae growth will be recycled and will stimulate heavier rooted weed growth. Oxygen depletion, which could result in a fish kill, is a constant danger in a heavily fertilized pond. This option should only be attempted after consulting a fisheries management biologist.

Chemical control

Chemical plant control is not a simple matter. Frequently, only a small difference exists between the dosage rates that will kill aquatic plants and that which can lead to a fish kill. The tendency is to apply too much herbicide. This can be disastrous because an overdose of some chemicals may kill fish or other organisms important to fish production. On the other hand, using less than the recommended amount may act as a growth stimulant and actually cause plants to grow faster.

There is no all-purpose weed killer. You must select the best chemical for controlling your specific problem plants. Chemicals are most effective in the spring when leaves are new and plants are growing rapidly. However, plants like cattails and water lilies that store food in their roots should be treated when they begin to bloom, otherwise you may kill just the tops and the roots will sprout new growth.

Regrowth of new plants from seeds is always a possibility, even if the current plants are completely eliminated. Most treatments provide temporary control and have to be repeated each year or several times each year. Chemical aquatic plant control in spring-fed ponds and lakes is particularly difficult because it is hard to maintain effective concentrations of chemicals.



Note: *Send for the Conservation Department's aquaguide "Operating a Bottom Withdrawal Spillway" for help controlling plants in spring-fed ponds.*

While there are many disadvantages to using herbicides, chemicals are easy to apply with a hand sprayer and often produce rapid results. They are safe and effective when applied according to directions and can be selected to kill specific types of plants.

When choosing a chemical, be sure it will not harm the fish. Copper sulphate, for example, which has been used for algae control, should not be used extensively in fishing ponds. Fish food organisms may be adversely affected by copper, and fish reproduction may be reduced.

Do not adopt the attitude that more is better. Treating too large an area or overdosing costs more and will result in the decay of a large quantity of

vegetation, which will cause oxygen depletion and fish suffocation. For this reason you should treat no more than $\frac{1}{4}$ of the problem plants at two week intervals.

Precautions are printed on the label. For your safety and for the health of your pond, read the label of any chemical for precautions and warnings about its use. The label is the final authority on how to use a chemical correctly.



Tip: For more details about aquatic vegetation control recommendations, contact the Conservation Department office in your area.

Muddy water

Clay turbidity or muddiness is a result of a combination of factors but is primarily a result of water chemistry. The relative turbidity of a pond is a balance of the rate of settling of soil particles and the rate of resuspension, which is caused by erosion, wind action or aquatic organisms that stir up the mud. In other words, it is the balance of forces keeping the soil particles in suspension and those forces causing or allowing them to settle.

Soil type and water chemistry

To find out why your water is muddy, take a sample of the water in a clean, clear, glass half-gallon or gallon jar. Set the jar on a shelf away from any disturbance and observe how fast the mud settles to the bottom. Write the date on the jar.

If the water clears in a week or less, you can conclude that larval aquatic insects, crayfish, bullheads, channel catfish, carp, muskrats, soil erosion from bare soil or wave action in shallow water may be the main cause of the problem. On the other hand, if the mud has not settled after a couple of weeks, then the problem is water chemistry and soil type. In many cases, animals, erosion and chemistry are all involved. In some cases, once the silt particles are stirred into the water, they will not settle on their own.

For ponds with a chronic clay turbidity problem, the answer may be to leave the pond untreated and stock with channel catfish and fathead minnows – species that do not depend on sight to obtain food. Because food production will be minimal in such an environment, the fish will have to be artificially fed.

If, however, you want a good, well-balanced, fish population in your pond, you will have to take care of the problem. Muddiness due to soil type and water chemistry is the most difficult to correct.



Note: To test your sample, add 2 tablespoons of vinegar to your water sample. If it clears up overnight, this means that the following treatment probably will work.

Place two small square bales of good, dry, green alfalfa or clover hay per surface acre of the pond in the water along the edge in the early spring or summer. Anchor the hay in place in shallow water by pushing one corner into the soft mud with your foot. The treatment will not be effective if all the hay is placed or blown into one corner of the pond. Reapply the bales at 14-day intervals until the water clears, but no more than four applications should be made each year.

Weak organic acids similar to vinegar form as the plant material decays. The acids neutralize an electrical charge on the soil particles, allowing them to settle to the bottom. Besides clearing the water, the decaying vegetation stimulates growth of microscopic plants and animals that are important fish foods.



Caution: *Since decaying vegetation removes oxygen from the water, it is important to not use more than the recommended amount to avoid killing fish. Don't use uncured or fresh cut vegetation because it decomposes rapidly and may cause a fish kill.*

For more details: *Send for the Conservation Department's aquaguide on clearing muddy ponds.*

Another way of clearing muddy ponds is with agricultural gypsum. It tends to clear the water faster than the hay treatment, but it is more expensive. Also, it does not produce fish food as the vegetation treatment does.

Pounds of gypsum needed to clear a pond

Average depth*	Size of pond in acres					
	1/4	1/3	1/2	2/3	3/4	1
2.0	250	350	500	700	800	1,050
2.5	300	400	650	900	1,000	1,300
3.0	400	500	800	1,050	1,200	1,550
3.5	450	600	900	1,200	1,350	1,850
4.0	500	700	1,050	1,400	1,550	2,100
4.5	600	800	1,200	1,550	1,750	2,350
5.0	650	900	1,300	1,750	2,000	2,600

*Average depth is equal to 1/3 of the maximum measured depth.

Only use agricultural gypsum that is available at lumber yards or from fertilizer dealers. Scatter it evenly over the entire pond surface. If the water does not clear up within four weeks and if there is no run-off from rainfall,

wave action, erosion or other sources of muddiness, apply more gypsum – about $\frac{1}{4}$ of the original dose. Once the water is cleared, you may have to add one or two bags per acre each year to keep it clear. Use no more gypsum than necessary.

Aquatic organisms

Bottom-feeding fish like carp, bullheads or excessive numbers of channel catfish keep silt stirred up by rooting in the bottom sediments for food. Adult channel catfish may enlarge muskrat or other holes in the bank and create muddy water temporarily during the spawning season. Young channel catfish produced in the pond can be so numerous that, like bullheads, their feeding activities can create a very muddy pond. Harvest channel catfish before adults reach 15 inches to minimize reproduction.

Ponds containing bottom feeders are likely to stay muddy in spite of any kind of treatment. The only remedy is to remove the fish and restock with fish that aren't bottom feeders. If the water is clear, a good bass population will eat nearly all young catfish that are produced.

Crayfish and muskrats may muddy pond water by digging in banks and along shorelines, removing plants and loosening soil. Crayfish are readily controlled by bass. If crayfish are creating the problem, your bass population is seriously out of balance. Reduce bass harvest and consider supplemental stocking of adult fish.

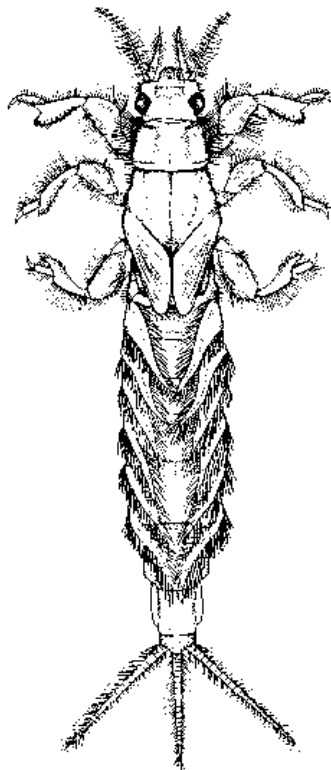
Burrowing larval mayflies can be so numerous that they stir up bottom sediments. If you scoop up a double handful of mud from the bottom in the summer and you see several

brownish-yellow inch long creatures with numerous legs and feathery appendages, your pond has too many burrowing larval mayflies. You may also see numerous pencil-size or smaller holes in the surface of the undisturbed bottom mud.

Too many mayflies means that the bluegill population is probably out of balance. Control of larval mayflies is uncertain at best. Stocking 300 to 400 2-inch bluegill per acre of water may provide some control, but the mayflies are only vulnerable to the bluegill during the late summer and fall as they emerge from tunnels and swim to the surface.

A rapid drawdown of the water level in summer to dry out the burrows and animals or in early winter to freeze out the insects may provide some control and give the bluegill a chance to control those remaining. A rapid

Burrowing mayfly nymphs can be found in most ponds. These insects provide food for bluegill.



drop in water level is necessary as the animals will attempt to leave their burrows and migrate down to deeper water if the water level drop is too slow.



Tip: *Electric bug lights placed over the pond in the late summer and early fall may attract and kill the emerging adults before they can reproduce. Place the lights so the insects fall back into the pond so the fish can feed on them.*

Leaking ponds

Some water loss can be expected in most new ponds until the surrounding soil becomes saturated. A 6-inch to 1-foot loss in a dry month due to evaporation also is normal. If the losses exceed these rates, you should look for a leak.

Ponds usually leak through a porous layer of sand, gravel or broken rock extending under the dam. The water may come to the surface some distance below the dam. Persistently soggy places, particularly in dry weather, anywhere in this area should lead you to investigate further. The seepage could be a wet-weather spring and may not be related to a leak from the pond.

Leaks are difficult to locate. If the water level stops dropping, you can assume that the leak originates at or above this water level. Attempts to seal the leak should be concentrated above this level. Several different methods are used to stop leaks. The one to use depends upon the type of leak, type of soil and availability of equipment. Cost also is an important consideration in some cases.



For more information: *To find the best method of repairing a leaky pond, send for the Conservation Department's aquaguide "The Problem of Leaky Ponds."*

Bentonite, a volcanic clay that swells when wet, has long been recommended for sealing leaks. It is most effective in ponds that do not have fluctuating water levels and on soils with a high proportion of coarse-grained particles.

Polyphosphate chemicals are the most effective materials for use in the red clay soils in the Ozark highlands. You should seek technical assistance from the local office of the Natural Resources Conservation Service in choosing the best method for this type of soil.

Clays or other suitable soil blankets may be used to seal a leaking pond. The determining factors are availability of material and cost of moving it to the pond. The amount needed and methods of application should be discussed with the Natural Resources Conservation Service.

Sometimes leaks can be stopped by compacting the existing soil. The clay content should be at least 10 percent for this method to succeed.

Other methods used in special cases include: sealing with flexible

membranes of plastics and butyl rubber or trampling by hogs or cattle. This last suggestion is not generally recommended, but it has been known to work in some ponds. It should be used only as a last resort, just before you decide to destroy the pond. Sealing sometimes results from feeding livestock on the wet pond bottom for a few days before it starts to fill with water. The livestock should be removed from the pond drainage after the leak is stopped since their activity may cause the water to become muddy.

Fish diseases and parasites

Fish can become ill with viruses, bacteria, fungi and parasites and, in severe cases, will die. Fish are more vulnerable to diseases when they are overcrowded because many disease organisms are easily transferred from fish to fish. Overcrowding also causes stress, which causes fish to be more susceptible to illnesses.

Fish disease problems are more common in the spring. When the water temperatures start to rise, disease organisms may increase quickly and test the fish's immune systems. Fish also may become stressed in late winter due to low oxygen concentrations or a lack of food. A logical question is: What is wrong with my fish, and what can I do about it? The answers are not simple. Few people are trained in diagnosing fish diseases and parasites. Treatment, if available, is expensive and difficult to administer because you have to treat the entire body of water. Under most conditions, treatment is neither practical nor economically feasible. Contact your local Conservation Department office for advice on your specific problem.

Parasites at normal, low population levels usually have little effect on fish. However, when fish are stressed by unfavorable environmental conditions, parasite populations can increase rapidly and kill fish. Bacterial, viral and fungus organisms also can expand rapidly under these conditions and produce lethal infections. Disease outbreaks may kill individual fish, large numbers of one species or individuals of several species.

Common fish parasites, such as yellow and black grubs or flukes, are occasionally found under the skin of bass, bluegill and sometimes channel catfish. To control these parasites, one would have to eliminate all the fish-eating birds, or all the snails or all the fish in or around your pond – none of which is a reasonable solution. Each of these animals is the host of one stage of the grubs' life cycle. However, one technique that might reduce the numbers of grubs is to introduce the snail-eating redear sunfish to your pond. This should decrease the abundance of both types of grubs in your fish. Because these parasites are destroyed by thorough cooking, fish infected with yellow or black grubs are safe for human consumption.



For more information: *Contact your local Conservation Department office or order the aquaguide on fish parasites.*

Wildlife and your pond

Many people enjoy watching animals that are attracted to the water. In a well-designed and properly constructed pond, wildlife will do little harm. If you want to attract more wildlife to your pond, contact the Conservation Department for information. However, occasionally an animal can be a nuisance. If control is necessary, you may consider the following.

Turtles

Turtles are generally harmless. Most are beneficial scavengers and are little threat to fish and wildlife. Only three species of turtles are commonly found in Missouri ponds. Two of these turtles, the red-eared slider and the painted turtle, are primarily vegetation eaters but will eat an occasional minnow, frog, crayfish or a sick fish. Sometimes these turtles annoy anglers by feeding on fish on stringers, but a live box will keep fish safe in areas with high turtle concentrations.

The common snapping turtle also is found in ponds. Even though they feed to some extent on small fishes and young ducklings, they are more apt to feed on a slow-moving, sick, crippled or dead fish and other dead organisms. One recent study showed that 36 percent of a snapping turtle's diet is aquatic vegetation.

Turtles are not a threat to the fish population and attempts to reduce their numbers usually result in no noticeable benefit to fish or fishing. The presence of turtles should not deter swimmers as all three species are shy in the water and will attempt to keep a maximum distance between themselves and a larger animal in the water. However, if they become a nuisance, you can easily reduce their numbers by catching them on a hook and line. Bait the hook with fresh beef, pork or parts of freshly caught fish. Like other nuisance wildlife, turtles can be removed during the closed season with a conservation agent's authorization.



For more details: Order the Conservation Department's "Turtle Control" pamphlet to find out more about these aquatic animals.

Muskrats

Permanent ponds in Missouri will have muskrats sooner or later. Muskrats can be an enjoyable addition to a fish and wildlife pond. Whether or not they actually do damage is dependent upon the way the pond is constructed. Burrows in banks around the pond usually cause little damage.

If muskrats become too numerous, control measures may be necessary. Eliminating muskrat food plants, especially on or near the dam, is good pond protection. The starchy plants that muskrats prefer include cattail, burr reed, bulrushes and arrowhead.



For more information: *Purchase a copy of “Water Plants for Missouri Ponds” from the Conservation Department to learn about plants that muskrats use for food.*

If damage requires immediate action, landowners or their agents may trap or shoot the animals at any time without a permit, provided they do not use any part of the animal for food or profit, and as long as they notify the local conservation agent within 24 hours of the action, according to Rule 3CSR10-4.130 of the Wildlife Code of Missouri.

Muskrats are easily removed by using traps. If done during the trapping season, the pelts may be sold by the holder of a trapping permit. The recommended trap for muskrat control, and the one many trappers prefer, is the No. 110 Conibear trap because it kills the animal outright. The standard No. 1 steel trap also is effective. See Rule 3CSR10-8.510 in the Wildlife Code.

Selection of trap sites is important and should be made with care. Traps set in runways, den openings, slides or near natural resting places are generally productive. Muskrats in your pond could be considered a bonus and harvested and sold during the legal trapping season.

Beaver

Beaver may create a problem by constructing a dam or plug in the water outlet of your pond or by cutting desirable trees and shrubs. Protect trees and shrubs by placing heavy woven metal fencing around the trunks.

Beaver may be controlled with trapping techniques similar to those used for nuisance muskrats. Because this is a larger animal, traps used must be larger. The regulations governing control of these animals are found in Rule 3CSR10-8.510 of the Wildlife Code.

Groundhogs

These animals may become a nuisance when they burrow into the downstream side of the dam. Denning activity may be discouraged by keeping the dam free from tall vegetation.

The most practical method of control is trapping. Contact the conservation agent in your county concerning other potential methods for discouraging groundhogs from using your dam as a homesite. Groundhogs may be removed according to Rule 3CSR10-4.130 of the Wildlife Code.

Fish-eating birds

Herons, kingfishers and other birds eat fish, but they normally do not impact a pond's fish population. Some of these are intermediate hosts of the yellow and black grub.

While it is commonly thought that these birds can carry fish or fish eggs from one body of water to another, there is no evidence that this is the case.

In general, birds should be considered a bonus, making your outdoor experience more memorable.

Bullfrogs

Most people enjoy bullfrogs and wonder why there aren't more around their pond. The first year or two, a newly stocked pond is a haven for frogs. But because tadpoles and frogs are favorite food for largemouth bass, their numbers diminish as the bass population becomes established.

Adult bullfrogs move to ponds in the spring to call and attract mates. They generally leave the larger ponds after the mating season and migrate to small bodies of water where they live the rest of the year. Good vegetation cover along the shoreline of your pond should be maintained as it provides a haven from terrestrial predators.

Snakes

Many types of snakes are attracted to the water in ponds, and they have no negative impact. The presence of these animals is an immediate cause for alarm for many people, but this concern is an injustice to this group of animals. We suggest that you sit back and observe snakes from a distance and learn from your observation.

If snakes become too abundant, the removal of shoreline vegetation and other cover, old boards, brush, rocks or trash will eliminate hiding places for their food and they soon will find more acceptable places to live.

Waterfowl

Waterfowl should be welcome visitors to your pond, but do not feed them as the numbers will increase in proportion to your ability and willingness to buy feed. Increased numbers can create serious problems due to the accumulation of droppings in the pond. These nutrients from the droppings contribute to the growth of excessive aquatic vegetation.

Appendix A

Missouri Department of Conservation

Box 180
Jefferson City, MO 65102-0180
573/751-4115

There are fisheries management staff in each of the following regional offices:

St. Joseph Conservation Service Center
701 N.E. College Drive
St. Joseph, MO 64507
816/ 271-3100

Kirksville Conservation Service Center
2500 S. Halliburton
Kirksville, MO 63501-4664
816/785-2420

Kansas City Metro Office
8616 E. 63rd St.
Kansas City, MO 64133-4783
816/356-2280

Columbia Conservation Service Center
1907 Hillcrest Drive
Columbia, MO 65201-6205
573/882-9880

St. Louis District Office
5632 Gravois Road
House Springs, MO 63051-2911
314/285-5051

Sedalia Conservation Service Center
1014 Thompson Blvd.
Sedalia, MO 65301-2243
816/530-5500

Camdenton Conservation Service Center
Route 2, Box 247
Camdenton, MO 65020-1115
573/346-2210

East Central District Office
P.O. Box 248
Springfield Road and Highway 185 South
Sullivan, MO 63080-0248
573/468-3335

Springfield Conservation Service Center
2630 North Mayfair
Springfield, MO 65803-5018
417/895-6880

West Plains Conservation Service Center
Box 138
618 Preacher Roe Blvd.
West Plains, MO 65775-0138
417/256-7161

Cape Girardeau Conservation Service Center
2302 County Park Drive
Cape Girardeau, MO 63701-1842
573/290-5730 or 573/290-5731

Other government agencies

Missouri Department of Natural Resources
Division of Geology and Land Survey
111 Fairground
Rolla, MO 65401-2909
573/368-2100

Division of Environmental Quality
Soil and Water Conservation Program
205 Jefferson St.
Jefferson City, MO 65102-0176
573/751-4932

United States Department of Agriculture
Farm Service Agency
(formerly the Agricultural Stabilization Commission)
601 Business Loop 70 West
Suite 225 Parkade Center
Columbia, MO 65203-2546
Phone No. 573/876-0932*

Natural Resources Conservation Service
(formerly the Soil Conservation Service)
601 Business Loop 70 West
Suite 250 Parkade Center
Columbia, MO 65203-2546
573/876-0910*

University Extension
2-70 Agricultural Building
Columbia, MO 65211
573/882-6385*

**Check your telephone book for the local office address and telephone number.*

Appendix B

Fish stocking policy

of the Missouri Department of Conservation

Requirements

- ✓ Part of the pond must be at least 8 feet deep.
- ✓ Livestock must be excluded from the pond with a permanent fence if the pond is smaller than 5 acres.
- ✓ Dams must be constructed for permanency and water tightness; drainage areas should be adequate, but not excessive, for water storage.
- ✓ Other than flathead minnows, fish must not be present prior to the stocking.
- ✓ All three species – bluegill, largemouth bass and channel catfish – must be stocked.
- ✓ Orders for individual species are not accepted.

The number of fish provided is based on surface area of the pond and a general soil fertility rating for the county where the pond is located. Fish are distributed to central locations in each county for pickup. Pond owners must be prepared to make a trip to accept delivery of bluegill and channel catfish in the fall and a trip in the spring to accept delivery of the largemouth bass. Fish must be handled according to instructions provided, and all fish must be stocked.

The Department representative inspecting the pond will determine the stocking rate to provide maximum numbers of fast-growing fish. Stocking rates are based on the biological and physical condition of the pond and its watershed. If the pond is properly managed, natural reproduction and growth will adequately replenish bluegill and bass removed by fishing. Catfish, however, will need to be restocked as harvested.

Ponds with undesirable species or that have low-quality populations can be renovated by removing all fish life. This must be done with permission and under the direction of the Conservation Department. For help in arranging a renovation, contact the local conservation agent or fisheries management representative in your district.

Pond stocking agreement

In Missouri, all wildlife, including fish, belongs to the people. The state regulates the harvest of fish and game through established seasons and limits. Landowners are allowed to take and use wildlife without state permit on the land on which they reside. They must, however, abide by the daily

take and possession limits unless they purchased their fish.

The pond stocking agreement recognizes the rights of landowners to control trespassing, while recognizing public ownership of fish and other wildlife.

This agreement strives to provide a reasonable amount of public use of the pond, subject to control by the owner under trespass laws. By signing the fish application, you agree to allow a reasonable amount of fishing in your pond. As a landowner, you retain absolute control over who may fish on your property. You do not have to allow everyone to fish your pond. Access to your pond remains in your control.

The Department does not give out the names of those people who receive fish for stocking. This information, however, is public and is available to those who ask to research the files.

How to order fish from the Conservation Department

- 1.** Fill out an application that is available from the local conservation agent, Conservation Department offices, University of Missouri Extension Center or the Natural Resources Conservation Service offices.
- 2.** By July 15, return the application to the agent or office from which you got it, or send it to the conservation agent in the county where your pond is located. Applications received after July 15 will be considered for the following year.
- 3.** A Conservation Department representative will inspect the pond and will either approve or reject the application.
- 4.** Applications are processed and letters of rejection or approval are sent in late August or September. Notice of delivery, including instructions on where to meet the truck, and how many and what size containers to bring are sent to approved applicants two weeks prior to distribution. Bluegill and channel catfish are delivered in September or October. Bass will arrive in late June of the following year.

To get your fish without delay, you should:

- ✓ draw a good map showing pond location on the back of the application.
- ✓ make sure that the name and address of the person to be contacted about fish delivery appears under “item 1” on the application.
- ✓ completely fill out all portions of the application that are required of the applicant.

If you have any questions about items on the application, contact your local Conservation Department representative for help.

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